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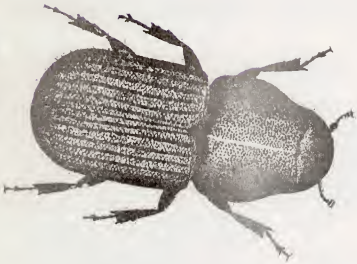
Protection of Individual Trees from Attack by the Mountain Pine Beetle

A Final Environmental Impact Statement



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Final Environmental Impact Statement
for Protection of Individual Trees from Attack
by Mountain Pine Beetle

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Abstract: This Environmental Impact Statement describes the proposed USDA Forest Service project for protection of individual lodgepole pine trees from attack by mountain pine beetle. The proposed project is to be conducted on three recreational areas (Homestake Picnic Ground, Delmoe Lake Picnic Ground and Campground Annex and Elder Creek Picnic Ground) located on the Jefferson Ranger District, Deerlodge National Forest. Four alternatives, including a "no action" alternative, are described. The environmental effects as they can be reasonably foreseen are discussed. A risk analysis concerning the use of carbaryl and its effect on human health is presented.

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SUMMARY

The Mountain Pine Beetle is the most damaging insect to pine trees throughout Montana. Epidemics of this insect are currently killing millions of trees annually at several locations in the state. Present biological evaluations on the Jefferson Ranger District, Deerlodge National Forest, have revealed dramatic increases in beetle populations and subsequent tree mortality. Susceptable trees (i.e., older, larger lodgepole pine) in three recreation areas on the District are in risk of being killed prior to the termination of the outbreak unless precautionary measures are taken.

This Environmental Impact Statement (EIS) describes eight alternatives considered by the USDA Forest Service (FS) for protection of individual lodgepole pine trees from attach by Mountain Pine Beetle (MPB). Approximately 1,800 trees are proposed for protection at Homestake Picnic Ground; Delmoe Lake Picnic Ground and campground annex, and Elder Creek Picnic Ground. The alternatives are evaluated and the preferred alternative is identified. The alternative implemented by the FS will serve as the primary management guide.

PURPOSE AND NEED FOR ACTION

Background Situation

The MPB (Dendroctonus ponderosae Hopk.) is a native bark beetle whose depredations affect management of the lodgepole pine (Pinus contorta var. latifolia Dougl.) ecosystem. Extensive forest areas have been decimated by this insect (Amman and others 1977; Safranyik and others 1974). Historically, millions of trees are killed yearly, and, during epidemics, more than a million trees can be killed in a single year on one National Forest. The beetle has killed an estimated 2 billion board feet per year since 1975 (Safranyik 1978). The beetle, like fire, has been active and has coexisted in lodgepole pine ecosystems almost as long as there has been lodgepole pine (Roe and Amman 1970). The large increase in ground fuel and associated increase in the probability of large, high-intensity fires following beetle epidemics suggests that the interaction between beetle infestations, fires, and lodgepole pine tends to perpetuate lodgepole pine, and hence, MPB epidemics. Scattered individual trees may be victims, but more often entire groups of trees are killed. Unchecked, these groups expand with succeeding beetle generations, and eventually entire stands suffer heavy mortality over large contiguous areas.

Depending on landowner objectives, these losses can have a catastrophic impact. For example, the value of a mountain home may be severely reduced by mortality of high-value shade and ornamental trees. From the timber producer's standpoint, infestations seriously affect even flow and sustained yield and make the task of converting unmanaged to managed forests very difficult. Epidemics disrupt management plans and affect local, regional, and national economies. Downfall following infestations hampers access and use by big game, livestock, and humans. Infestations affect recreation and esthetics, increase fire hazards, affect water and watershed management, and may increase the proportion of trees infected by dwarf mistletoe (Arceuthobium americanum Nutt. ex. Engelm.) (Wellner 1978). On the other hand, some managers favor grassland over timberland, and a beetle epidemic causes them much less concern. They may, however, establish this preference without fully considering other resource values--among them soil, water, and vegetation stability.

Mountain pine beetle epidemics also have major impacts on roadless and wilderness areas and national parks. Because the beetle is such a profound change agent in lodgepole pine ecosystems, the resource values and management objectives of these lands are usually modified to some degree by an epidemic. For example, although the effect on water quality and quantity of these lands may be minimal (Wellner 1978), wildlife, recreational, and visual resources can be impaired.

Most epidemics develop because there are large areas of unmanaged lodgepole pine forests. Periodically in these forests, endemic MPB populations develop to epidemic levels. In an outbreak, the beetle thins from above, first killing the older, large-diameter, more open-grown trees. As populations build, beetles eventually kill smaller and younger lodgepole pine less desirable for brood production. In general, the beetle attacks and kills proportionately more large-diameter than small-diameter trees (Cole and Amman 1969) and kills trees of largest diameter each year of the infestation. Infestations die out when all or most of the large-diameter trees are killed. The effect on productivity in stands containing an appreciable proportion of lodgepole pine (for example, >40 percent) is residual stands composed of inferior trees that are unable to adequately exploit the extra growing space provided them. Productivity is also affected by additional mortality caused by sun-scald, snow, windthrow, or other causes (Wellner 1978).

Behavior, Biology, and Life Cycle

The first evidence of infestation usually consists of pitch tubes, where beetles entered the tree, and boring dust in bark cracks and at the base of trees. Infested trees remain green until spring, when they can be detected from a distance as foliage dries and changes to pale green, then to light orange, and finally to bright orange-red by July. Emergence holes made from mid-July through early August signify the brood has emerged from the tree to attack green trees.

The MPB usually completes a single generation per year; however, up to 2 years may be required to complete the life cycle if cool temperatures at high elevations and in more northern latitudes delay development and emergence of beetles (Amman 1973; McCambridge 1974; Safranyik and others 1975).

Emergence and flight of new adults begin early in July and may continue through September. Although emergence may continue for a month or more, usually 80 percent of the beetles emerge within about 1 week (Rasmussen 1974). Initial attacks on pines usually occur on the lower 15 feet (4.4 m) of the bole. Unmated females make the initial attacks and release odors, called aggregating pheromones, that attract males and other females until a mass attack occurs on that tree and surrounding trees. When populations are too light to mass-attack trees, or the tree is successful in repelling attacking beetles, the tree remains alive and is termed an unsuccessful attack or pitchout. Sometimes a portion of a tree is successfully infested and brood is produced without killing the tree. This is called a strip attack. Successful attacks are usually accomplished by a single generation of beetles. As populations increase from year to year, the mass-attack phenomena is heightened and larger groups of trees are infested and killed. The unmated female initiates the egg gallery and, following mating, lays eggs in alternating groups along the sides of the gallery. Egg galleries average about 12 inches long (31 cm) and are usually completed by late October when temperatures are too cold for the beetles to continue boring and ovipositing. Most eggs hatch in about 2 weeks; however, more time is required as temperatures begin to cool in the fall.

Newly hatched larvae feed on the phloem, constructing galleries that extend approximately at right angles to egg galleries. Larvae cease feeding in the fall, overwinter, and begin feeding again in April, completing development in June. Larvae change to pupae within cells excavated in the bark and sapwood. Pupae then transform to adults, usually from late June to mid-July.

In addition to the action of larvae feeding in the phloem, fungi and possibly other microorganisms aid in killing the infested trees (Safranyik and others 1975). New adults pick up blue stain fungi and probably other microorganisms in special structures located in their mouths while feeding in the bark before emerging. Blue stain fungal spores and yeast and bacterial spores are carried to newly attacked trees, where they develop, eventually spreading throughout the sapwood. The microorganisms commence growth in living phloem and xylem tissues soon after the beetle starts gallery construction. This hinders translocation in the xylem and makes moisture conditions under the bark more favorable for beetle development.

Concerns

The continuing MPB infestation in the Northern Rocky Mountain Region has focused attention of the public and forest managers on the impact and possible loss of campgrounds, some of which are unique and perhaps irreplaceable. Major concerns brought forward by the Agency concerning the proposed project are:

1. impact of MPB on recreational opportunities and values,
2. affect of project on soil and water,
3. affect of project on wildlife and domestic animals,
4. cost effectiveness,
5. affect on aesthetic values,
6. human health and safety,
7. loss of existing capital investment at recreation sites,
8. public involvement and notification.

Economic Considerations

Economic losses resulting from the mortality caused by MPB within the picnic grounds proposed for the project are difficult to quantify. However, without imposing a concerted tree protection management program, the Agency is faced with a replacement-in-kind situation. The areas have capital improvements such as toilets, picnic tables, fire circles, barbeque-type stoves, and water delivery systems. Capital investment necessary to replace each of existing sites is estimated at $110,000 for Delmoe Lake Picnic Ground, $90,000 for Homestake Picnic Ground, and $50,000 for the Elder Creek Picnic Ground. In addition, the aspect of a water-enhanced recreational opportunity is of unique value that may be irreplaceable at the Delmoe Lake and Homestake Lake sites.

FS Participation

Laws applicable to the FS that govern in suppression and eradication projects are:

1. The Cooperative Forestry Assistance Act of 1978 (P. L. 95-313), which incorporated provisions of the Forest Pest Control Act of 1947 (now repealed), provides authority for Federal/State cooperation in forest insect and disease management.

2. The National Environmental Policy Act of 1969 (P. L. 91-190 42 USC 4321 et seq) requires detailed environmental analysis of proposed major Federal actions that may affect the quality of the human environment.

3. The Federal Insecticide, Fungicide, and Rodenticide Act of 1972 (7 USC 136) as amended requires that insecticides used in suppression and eradication projects be registered by the EPA.

The following FS goals are considered in the evaluation of the MPB individual tree protection project:

1. A principal FS goal is to assure an adequate supply of high-quality food and fiber and a quality environment for the American people. The FS gives special emphasis to the development and use of efficient and environmentally acceptable integrated pest management systems. All methods including the use of chemical pesticides, are considered in integrated pest management projects.

2. FS policy is to protect and preserve the forest resources of the Nation against destructive forest insects and diseases. Pest outbreaks will be prevented or suppressed by methods that will restore, maintain, and enhance the quality of the environment. These objectives are attained on non-Federal lands through cooperation with State foresters or equivalent State officials. Pests are suppressed directly on National Forest System lands and in cooperation with responsible officials on other Federal lands. Projects approved for cooperative financing must meet FS standards for environmental, biological, and economic acceptability and must meet FS Federal role criteria (FSM 3430). Approval is based on the results of an environmental analysis conducted in accordance with NEPA regulations.

ALTERNATIVES INCLUDING THE PROPOSED ACTION

Range of Alternatives

The following summarizes the range of alternatives that were considered.

1. No Action - This direction would involve letting nature take its course and investing no time or dollars in vegetative manipulation, maintenance of facilities or improvements.

2. Salvage and Replant - As trees are infested with mountain pine beetle they will be removed by a salvage logging operation. All slash will be handpiled and burned. As openings occur, tree and brush seedlings will be selectively planted to provide afternoon shade and screening between units.

3. Clearcut and Replant - Harvest all lodgepole pine trees now with a logging operation. Reforestation would be done with coniferous and hardwood species. Placement of seedlings would be done selectively to provide for afternoon shade and screening. Some revegetation with grass and brush would be needed to protect the soil from erosion and compaction. The objective would be to have 70 percent treeless openings and 30 percent tree cover. This would entail planting approximately 1,000 seedlings the first year after harvest.

4. Individual Tree Protection with 1 Percent Formulation of Sevin XLR - This involves treating 1,846 trees within three recreation sites with Sevin XLR (carbaryl) insecticide. The objective would be protection of the existing trees throughout the beetle epidemic.

5. Clearcut and Refurbish - This is essentially the same treatment as alternative 3 except reforestation would be done with 6- to 10-feet tall trees. Approximately 90 such trees would be needed per acre to provide adequate afternoon shade and screening.

6. Biological Control - This involves the use of natural predators to the mountain pine beetle in controlling the epidemic within the recreation sites until the population collapses naturally.

7. Diatomaceous Earth - This involves the application of diatomaceous earth in a slurry to selected trees for protection from mountain pine beetle.

8. Thinning - Selective removal of trees evenly distributed through the existing stand to increase the amount of sunlight reaching the tree boles and the ground. The objectve of this treatment would be to increase the vigor of the tree thereby reducing its susceptibility to successful attack by the mountain pine beetle.

Alternatives 5, 6, 7, and 8 were dropped from futher consideration for biological and economic reasons. Biological control of the mountain pine beetle and control with diatomaceous earth have not been sufficiently researched to qualify them as effective treatments. Refurbishing the campground with 6 to 10-foot trees and the associated expenses to insure survival would not be feasible economically. The effect of thinning is not expected to be significant enough or fast enough to provide the desired level of protection during this outbreak.

Alternatives Considered

The alternatives presented in this DEIS meet the Federal suppression protection objectives, address issues and concerns raised during evaluation activities, and adhere to FS guidelines governing participation in suppression/protection projects.

The four alternatives considered and evaluated are:

1. No action.

2. Clearcut and replant.

3. Salvage logging.

4. Application of 1 percent Sevin XLR (carbaryl) for individual tree protection.

COMPARISON OF ALTERNATIVES

No Action

The no-action alternative means that no effort would be expended to protect trees in the subject campgrounds.

Salvage and Replant

It is estimated that over the next 4 years, 100 percent of the lodgepole pine trees >6 inches DBH within the subject campgrounds will become infested with MPB and die. As these trees become infested, they will be felled and removed from the campground. All slash will be handpiled and burned. These multiple efforts will result in openings within the campground which will be planted to less susceptible coniferous and appropriate hardwood seedlings.

Clearcut and Replant

This alternative provides for the harvesting of all lodgepole pine trees >6 inches d.b.h. within the subject campgrounds. Reforestation would be accomplished with less susceptible conifers and appropriate hardwood species. Replanting would begin immediately after adequate silvicultural plans could be prepared to provide adequate and meaningful recreational values as well as enhanced MPB resistance. It will be necessary to provide immediate revegetation of grass and shrubs to protect against soil compaction and erosion. If the forested appearance of the recreation areas is to be maintained, lodgepole pine will still dominate the conifer vegetation because of elevation and site characteristics present.

Individual Tree Protection with 1 Percent Formulation of Sevin XLR (Preferred Alternative)

The selection of this alternative would result in funding this project using Sevin XLR whose active ingredient is carbaryl. Although the registered rate of Sevin XLR (EPA Reg. No. 264-333) consists of a 2 percent formulation, recent field experiments have demonstrated that effective tree protection (>90 percent) can be achieved with a 1 percent formulation (P. Shea and M. McGregor unpublished data 1985). Further, these field experiments indicate that 2 years of protection can be expected. Therefore, if a 4-year time frame for protection of individual lodgepole pine is needed, this will require two applications to achieve the stated objectives. A 4-year time frame is envisioned for the MPB population to move through the area and, therefore, lessen the probability of attack on residual campground trees.

Although thousands of trees in the vicinity of the campgrounds are threatened, it is only feasible for logistic and economic reasons to protect selected high-value trees.

Campground managers have selected 1,846 trees for protection, these are distributed in the following manner: (1) Homestake Picnic Ground - 205 trees (2) Delmoe Lake Picnic Ground and Campground Annex - 1,566 trees, (3) Elder Creek Picnic Ground - 75 trees.

Treatments will be made using a truck-mounted FMC Bean Hydraulic sprayer calibrated to deliver 2 gallons of formulated Sevin XLR in 45 seconds. This quantity is enough to treat an individual tree (>6 inches <40 d.b.h.) to a height of 30 feet.

AFFECTED ENVIRONMENT

Host Vegetation

The most important factors affecting survival of the beetle brood and the expansion of beetle populations to epidemic levels are climate, habitat type, size and age of trees, phloem thickness, moisture content of phloem, stand structure, and stand density.

Climatic Factors

Climate can significantly influence the dynamics of beetle populations at extreme northern latitudes and at high elevations in more southerly latitudes (Amman 1976). At the lower elevational zone (below 4,920 ft (1,500 m) at lat. 49° N. to 8,528 ft (3,000 m) at lat. 39° N.), temperatures generally favor survival and multiplication (Amman and others 1977; Safranyik 1978), and the beetle poses a continuous threat to lodgepole pine of susceptible age and size. Above this zone, climate becomes progressively adverse to brood development and survival. Broods tend to undergo a 2-year cycle and become poorly synchronized with climate (Amman 1973) because the least cold-hardy life stages (egg, pupa) coincide with winter. Because of reduced brood survival, infestations become less frequent and intense with increasing elevation, although ample food supply exists (Amman and Baker 1972; Amman and others 1972). Therefore, stands of lodgpeole pine at high elevations often contain a higher proportion of large-diameter trees than stands at low elevations.

Habitat Types

Habitat types are reflections of differences in environments. The beetle/lodgepole pine interaction varies in different habitat types. For example, in southeastern Idaho and northwestern Wyoming, 44 percent of the lodgepole pine stands were infested in the Abies lasiocarpa/Vaccinium scoparium habitat type (h.t.) between 6,500 and 8,500 ft (1,980 and 2,590 m) elevation; 92 percent were infested in the Abies lasiocarpa/Calamagrostis rubescens h.t. between 6,000 and 7,800 ft (1,828 and 2,377 m) elevation (Roe and Amman 1970).

When h.t.'s were grouped into four classes on the Gallatin National Forest, Montana, lodgepole pine mortality from the beetles was shown to vary among h.t.'s and decreased in the following order: Douglas-fir h.t., Engelmann spruce h.t., subalpine fir h.t., and lodgepole pine climax h.t.

Among the dry habitat types, mortality of the lodgepole pine basal area in trees ≥8 inches (20 cm) d.b.h. ranged from 42 percent at 6,000 ft (1,828 m) elevation on Pseudotsuga menziesii/Calamagrostis-Carex-Carex phase h.t. to 25 percent at 8,000 ft (2,430 m) elevation on the Abies lasiocarpa/Vaccinium scoparium-Vasc phase h.t. Among moist habitat types mortality ranged from 40 percent at 5,800 ft (1,727 m) elevation on the Picea/linnaea borealis h.t. to 13 percent at 7,800 ft (2,377 m) elevation on Abies lasiocarpa/Alnus sinuata h.t. (McGregor 1978).

Good sites generally have trees with thicker phloem than poorer sites. Since phloem thickness is the most important factor determining brood production where climate is not limiting, good sites can be expected to suffer more frequent and intense beetle infestations if unmanaged.

Tree Size and Age

Because the beetle selects and kills proportionately more large-diameter than small-diameter trees, large infestations require at least some lodgepole pine larger than 8 inches (20 cm) in diameter. The beetle selects the largest trees in a stand first, as well as over the life of the outbreak. Large trees usually have thicker phloem, the food of developing larvae, and maintain higher moisture levels throughout beetle development than small trees. These are the principal factors responsible for greater beetle production in large than small trees (Amman 1969, 1973; Cole and others 1976). The beetle's behavior in selecting trees of larger diameter is probably adaptive and related to the higher probability of encountering the thick phloem that results in higher progeny survival (Amman 1975).

When older stands of trees are infested, young trees in nearby stands are often attacked and killed. Because brood production and survival are low in young trees, however, young trees alone are not capable of sustaining an outbreak. The average age of trees in which outbreaks occur is about 80 years (Safranyik and others 1974; Amman and others 1977). Outbreaks rarely begin in stands 60 to 80 years old. Phloem in trees under 80 years old is usually more spongy and resinous than that of older trees (Amman 1978). This may be because of larger cells and less phloem compression in phloem of young trees (Cabrera 1978).

Stand Structure and Density

Stand structure is important in beetle dynamics because of the beetle's preference for large-diameter lodgepole pines (Cole and Amman 1969). Losses of lodgepole increase as the proportion of lodgepole 9 inches (23 cm) or larger d.b.h. increases in stands (Amman and others 1972). As large-diameter trees are depleted from the stand, beetles turn to small trees; however, few beetles survive in small trees because of thin phloem and excessive drying. The number of beetles and infested trees subsequently declines (Cole and others 1976).

Under epidemic conditions, beetles depend upon the best trees in stands for a population buildup. Epidemics usually start in full-crowned trees, but not necessarily the oldest or biggest, located along the outer edge of the timber bordering open rangeland or on lake and stream shores (Washburn and Knopf 1959). Trees at edges or in more open stands are usually growing faster than those within stands and, consequently, have thicker phloem. In more open stands, the proportional losses of lodgepole pine are therefore much greater (Amman 1978).

Stands with the greatest amount of dwarf mistletoe infection have proportionately fewer trees killed than do stands with little or no infection (McGregor 1978). This is because trees with medium to heavy dwarf mistletoe infection in the crown have significantly thinner phloem than do uninfected trees (Roe and Amman 1970).

The killing of the largest trees as they become mature, or slightly before they reach maturity in persistent and climax stands suggests an adaptation by the beetle that results in a more continuous food supply for future generations (Amman 1977).

Treatment Sites

The treatment sites are located on the Jefferson Ranger District, Deerlodge National Forest. All areas are in Jefferson County.

Name	Homestake	Delmoe Lake	Delmoe Lake	Elder Creek
Use	Picnic	Picnic	Campground (proposed)	Picnic
Location	S13,T2N,R7W	S28,T3N,R6W	S28,T3N,R6W	S14,T5N,R5W
Elevation	6270	6120	6120	5480
Slope	5-10%	10-15%	5-10%	5-10%
Aspect	SE	E	E	E
Tree cover	(Immature-Mature) LP 1/	LP (Mature)	LP (Mature)	LP&DF 2/ (Mature)
Habitat Type	PSME/CARN4/	PSME/CARN	PSME/CARN	PSME/CARN
Water Present	Yes (adjacent to Homestake Lake)	Yes (adjacent to Delmoe Lake)	Yes (adjacent to Delmoe Lake)	Yes (adjacent to Elder Cr., 200 ft. from Little Boulder River)
Fishery Improvements	Yes (Trout) Tables Fireplaces Outhouses	Yes (Trout) Tables Fireplaces Outhouses	Yes (Trout) None --- ---	Yes (Trout) Tables Fireplaces Outhouses
Season	5/25-10/15	4/15-10/15	---	5/15-9/30
RVD's 3/	10,800	6,400	---	1,600
Proposed treatment	5 ac LP >6" d.b.h. App. 205 trees	4 ac LP >6"d.b.h. App. 1,128 trees	4 ac LP >6" d.b.h. App. 438 trees	1 ac LP >6" d.b.h. App. 75 trees

1/ Lodgepole Pine
2/ Douglas-fir
3/ Recreation Visitor Days
4/ Psendotsuga menziesii/Calamogrostis rubescens (Douglas-fir/Pine Grass
Treatment is planned to begin in late June.

The consequences of not treating these areas and the subsequent loss of mature lodgepole pine trees would be the reduced visual quality of the areas which would reduce usage. Use reduction is likely to be moderate at Homestake and Elder Creek because of the smaller number of trees likely to be affected and the diversity afforded by immature lodgepole at Homestake and mature Douglas-fir at Elder Creek. The impact on use at Delmoe Lake is likely to be significant because both the picnic area and proposed campground annex are completely dominated by mature, high-risk lodgepole pine. Priority for treatment then is Delmoe Lake Picnic Area, Delmoe Lake Campground Annex, Homestake Lake, and Elder Creek.

Physiography

The project areas are relatively flat to not more than 15 percent slopes. All exposures are E-SE at an elevation of 5,480 to 6,270 feet. Elder Creek is a year-long stream that drains into the Boulder River. The other areas abut Delmoe and Homestake Lakes.

Watershed

Delmoe Lake is within 8 air miles from Butte, Montana and Homestake Lake is 5 air miles from Butte. Water quality is good on both areas and most of the area around Delmoe Lake and Homestake Lake is drained by Pipestone Creek. Elder Creek is 5 air miles from Boulder, Montana. Water from all areas is used downstream by farmers and ranchers. None of the areas serves as a municipal watershed.

Timber

Almost half of the area adjacent to the recreation sites has tentatively been identified as being suitable for timber harvest. Lodgepole pine is identified as the principle species.

Stands within the Delmoe Lake area are even-aged, mature to immature (100-150 years old) lodgepole pine. Stands in the Homestake area are mixed age classes of immature to mature lodgepole pine. Mixed species of mature-overmature (100-150 years old) Douglas-fir and lodgepole pine comprise the stand makeup in Elder Creek Area.

Beetle activity began in the Homestake Pass area in 1981 and has increased and spread over more than 6,000 acres of susceptible lodgepole pine type. The ratio of beetle killed trees was 1:25 from 1984 to 1985. This follows a sharp decline in beetle populations and tree mortality caused by extremely cold temperatures during the winter of 1983-84. Tree mortality from MPB has required annual removal of high-risk trees from these recreation sites and along travel routes for several years. The epidemic is predicted to continue with an increase in tree mortality and acres infested during the next few years.

A beetle salvage sale of 101,000 board feet(BF) is active 2 miles north of the Homestake Recreation area. A 33,000 BF salvage sale is active 2 miles south of Delmoe Lake Campground. The 2-3 MMBF Delmoe-Halfway sale is planned between Homestake and Delmoe Lake in the immediate future. Three MMBF will be removed 1 mile NW of the Elder Creek Campground in 1988 by the proposed Moose Meadow sale.

Nontarget Organisms

There are many species of insects, amphibians, reptiles, fish, birds and mammals that spend some time within or adjacent to the subject campgrounds. Nontarget organism use varies by species and, in some cases, whether or not human use is ongoing. Deer, bear, and elk signs are visible and the normal complement of ground-dwelling mammals and birds can be found. Invertebrates represented by various terrestrial and semi-aquatic species are present at various times of the year depending on species-specific phenologies.

Some invertebrate species are expected to be temporarily adversely affected, but long-term population effects on these various species are highly improbable (see carbaryl-Appendix A).

Recreation

The areas receive a fair amount of motorized recreational use including fall elk and deer hunting, picnicing, fishing, and swimming. It is close for day hikes to Butte, Whitehall, Boulder and other local residents.

History and Archaeology

Cultural resources surveys have been conducted in the area. There is moderate potential for historic logging and mining sites and/or prehistoric occupational and travel sites.

Economics

A least cost analysis of the four alternatives was completed and is located in Appendix C. The undiscounted costs and benefits(stumpage revenues) used in the analysis are displayed under the environmental consequences for each alternative on following pages of this statement.

Threatened and Endangered Species

There are no known threatened or endangered species within the project area.

Wildlife

The areas are important summer habitat for elk, moose, and mule deer. Numerous other nongame animals and birds are found in the areas. Big game species are all hunted in the areas.

Fisheries

Delmoe Lake and the Little Boulder River support year round trout populations. Delmoe Lake is heavily fished during summer and fall months, and the Little Boulder River receives moderate to heavy use. Although Homestake receives some activity, heavy algael blooms kill fish yearly. Elder Creek serves as a rearing stream for the Little Boulder River.

Livestock

Delmoe Lake area supports a substantial amount of grazing. Most of this occurs around the Whitetail Reservoir, and between Homestake Lake and Delmoe Lake. Opportunities exist to increase this by water development, fencing, vegetation manipulation and development of transitory range from timber harvesting.

Transportation

The areas are served by Interstate 90 to the south with easy exit and access by forest roads.

Minerals

Most of the area contains moderate to low potential for minerals with pockets of high potential. Deep and large molybdenum deposits are likely near the southwest boundary, plus numerous areas of placer gold potential. The areas now have 50 mining claims within them.

ENVIRONMENTAL CONSEQUENCES

NO ACTION

Selection of the no-action alternative for the subject campgounds will result in the almost total elimination of all trees in excess of 6 inches d.b.h. from attack by MPB. Taking into consideration the amount of MPB activity already within the subject campgounds, and especially the levels of infestation in adjacent lodgepole pine stands, it is projected that the subject campgrounds will be lost within 3-4 years. Because dead trees present a safety hazard which increases over time, the subject campgrounds may have to be closed to public use within 1-2 years. The total loss of campgrounds due to MPB activity has become of increasing concern in the Northern Region. As recently as 1984 the McGregor Lake Campground on the Tally Lake Ranger District of Flathead National Forest, some 35 miles east of Kalispell, was entirely clearcut due to excessive lodgepole pine mortality. The causative agent was MPB. In addition, several campgrounds and other valuable administrative sites have been lost in recent years on the Targhee National Forest due to MPB. Cost to replace the subject campgrounds at a different site ranges from $100,000 to $200,000. However, the Delmoe Lake Campground offers a unique recreational experience because of the water-enhanced setting and may be irreplaceable.

CLEARCUT AND PLANT

Implementation of this alternative would result in the loss of the subject campgrounds for at least 10-15 years. Best estimates are that it would take this many years for the planted vegetation to be mature enough to provide enough shade and screening to attract recreationists. Logging activity would cause some disturbance and other habitat alterations would, at least temporarily, have an adverse effect on some indigenous fauna.

Removal of the existing stand would be done by a commercial timber sale. Cleanup of unmerchantable trees and replanting would be accomplished with FS personnel. Expected revenue from sale would be approximately $1854.

Cost:	Sale preparation	$1000
	Sale administration	$1472
	Slash cleanup (FS cost)	$1030
	Reforestation (trees and FS labor)	$5740
	TOTAL COSTS	$9242

SALVAGE AND REPLANT

Selection of this alternative, similar to the clearcut and replant option, would result in the loss of the subject campground for at least 10-15 years. Unlike the previously discussed alternative, use could continue until removal of dead trees was so extensive that the recreational value was negligible.

Eventually residual stand density of lodgepole pine would be such that the safety hazard from windthrow would necessitate removal and subsequent closure of the campgrounds. After hazard tree removal, slash and nonmerchantable trees would be handpiled and burned. Replanting to less susceptible coniferous and hardwood species would occur on a periodic basis but would be of little recreational value for 10-15 years. It should be clearly understood that this option requires several "removal" entries into the subject campground with all the attendant impacts on soil, flora, and fauna. Expected revenues from timber sale would be approximately $1442.

Cost:	Sale preparation	$1200
	Sale administration	$1472
	Slash cleanup	$2575
	Reforestation (trees and FS labor)	$5740
	TOTAL COSTS	$10987

INDJVIDUAL TREE PROTECTION WITH 1 PERCENT SEVIN XLR (Preferred Alternative)

Sevin XLR is a preventive insecticide. It does not effect the tree directly but does protect it from attack by the mountain pine beetle.

Selection of this alternative would result in the treatment of 1,846 lodgepole pine trees with a 1 percent formulation of Sevin XLR PLUS (carbaryl the actual ingredient), 205 trees, Homestake Picnic Ground; 1,566 trees, Delmoe Lake Picnic Ground and Campground Annex; 75 trees, Elder Creek Picnic Ground.

Sevin XLR is a suspension of carbaryl insecticide in a water based flowable with sticking agents. Carbaryl is a broad spectrum, widely used insecticide that has been registered for use since 1959. The State of Montana and the Environmental Protection Agency have registered it for use as a mountain pine beetle preventive spray (EPA Reg. No. 264-333; Montana Reg. No. 03533). Trees would be treated prior to MPB flight in 1986 to provide individual tree protection. All trees would be individually treated from the ground using a truck-mounted FMC-Bean Hydraulic Sprayer time calibrated to deliver 2 gallons of final formulation in 45 seconds. This results in total coverage of each tree bole to a height of 30 feet.

Sevin XLR PLUS would be applied in a 1 percent solution with water. Label directions instruct the application of 1 gallon of solution per 50 square feet of bark surface. Application rates would vary by tree, but on average each tree would require about 2 gallons of spray mixture.

According to the label, 1 gallon of Sevin XLR PLUS would be mixed with 46 gallons of water in order to obtain a 1 percent solution. One gallon of Sevin XLR contains 4 pounds of carbaryl. Thus, 47 gallons of solution would contain 4 pounds of carbaryl. Forty seven gallons of solution will treat about 24 trees. Each tree would be treated with about 0.17 pounds of carbaryl.

Because the insecticide will be applied directly to the bark of the trees, very little will be released into the nontarget environment. Most would be bound by and absorbed in the tree's bark. Haverty et al. (1983), in experiments conducted to quantify the amount of drift and worker exposure resulting from ground application of individual trees, found that greater than 80 percent of the material applied stays on the tree.

In addition, about 45 percent of the material that fell to the ground was deposited within 2 meters of the base of the tree. The amount of material decreases rapidly as distance from the treated tree increases; 50.2 ug/cm^2 at 1 meter; 14.2 ug/cm^2 at 3 meters; 2.3 ug/cm^2 at 5 meters; .3 ug/cm^2 at 8 meters; 0.0 ug/cm^2 at 12 meters.

The MPB has a complex and varied array of natural enemies that include parasitoids and vertebrate and invertebrate predators. In any application of insecticide to a target pest there is major concern for the effect of the treatment on these components since they are directly linked to the target insect. However in this case the objective is to prevent colonization of MPB in individual trees and thereby prevent the complement of natural enemies from being drawn to the treated trees.

In 1980, the EPA conducted an intensive review of the available toxicology literature on carbaryl. The agency concluded not to cancel or change the registration classification of this insecticide (Federal Register, Vol. 45, #241, pp. 81869-81876; December 12, 1980). For a review of the literature on the effects of carbaryl on nontarget organisms see Appendix A.

Costs: Costs were estimated on needed manpower from previous protection treatment projects and 1% Sevin XLR PLUS retail price.

77 gal of Sevin XLR PLUS @ $19.41/gal	$1494.00
Wages to apply insecticide @ 1.80/tree	3300.00
Protective clothing and supplies	1000.00
TOTAL COSTS	5794.00

HUMAN HEALTH IMPACTS OF PESTICIDE APPLICATION

The application of pesticides, be they insecticides or herbicides, can cause public controversy because of potential human health impacts. An extensive human health risk analysis of the potential health impacts of spraying carbaryl to control mountain pine beetle is provided in Appendix B. A brief summary of salient findings of this analysis is provided in this section.

The mode of action of carbaryl in both insects and in mammals is fairly well understood. Carbaryl lowers the cholinesterase level in many animals including humans. Cholinesterase splits acetylcholine, the chemical responsible for forming the bond necessary to carry an impulse through the nervous system. If the acetylcholine is not split, the nerve impulse is repeated again and again. A severe lowering of cholinesterase may result in disruption of nerve function. The cholinesterase depression is reversible in most animals, including humans. Some carbaryl may be stored temporarily in body tissues, but it does not accumulate.

Testing of carbaryl on humans has also shown some reversible effects on kidney function. The significance of these effects on human health is not completely understood. These findings are further discussed below and in Appendix B.

An important concept in determining the significance of a potential dose to humans is the no-observed-effect level (NOEL). In a dosing study with animals (or humans) the highest level of compound given to the test organism that produces no effects on the organism is called the no-observed-effect level.

As an additional precaution, recreation sites will be closed for 10 days after Sevin XLR application. Application and closure will be timed so that recreation sites remain open during the peak use July 4th weekend. By avoiding peak use periods, adjacent dispersed recreation sites will be capable of handling the recreational demand during the 10-day closure.

Researchers can conduct a variety of tests investigating a variety of effects such as birth defects, reproductive impacts, nervous system disruptions including cholinesterase inhibition, liver and kidney function, blood chemistry, etc.

Allowances must be made for the uncertainty of extrapolating from animal tests to human impacts. Allowances must also be made for the variation among humans in their response to chemicals. As discussed in Appendix B, the U.S. Environmental Protection Agency has divided the NOEL for carbaryl by a factor of 100 to set the Acceptable Daily Intake (ADI) for carbaryl. It should be noted that the ADI is a presumed safe dose of a compound that could be taken every day for a lifetime. Possible doses from carbaryl spraying would be transient.

All possible doses to the general public are below the ADI for carbaryl. Doses include unlikely scenarios such as consuming sprayed wild foods (wild food such as berries would not be ripe during spraying), and consuming wild game that has consumed sprayed foliage (hunting season occurs several months after spraying).

In addition, dose estimates for members of the general public are below levels that have caused minor reversible impacts on kidney function in human tests.

The highest doses resulting from spray applications would occur to workers responsible for application. Although the deposition of spray on worker skin has been measured under circumstances similar to spray conditions in Region 1, the amount actually absorbed into the body has not been measured. Three estimates of dermal absorption are used in estimating worker dose (1 percent, 10 percent and 75 percent). In addition, a low, worker-protection scenario and a normal, worker-protection scenario are analyzed. If normal protective clothing is worn, all worker dose estimates are below the carbaryl ADI and kidney effect levels for all dermal absorption rates. The dose exceeds the ADI only if little protective clothing is worn (i.e., sleeveless shirt and no gloves) and a dermal absorption rate of 75 percent is assumed or a dermal absorption rate of 10 percent and poor application techniques resulting in high exposure (with little protective clothing) are assumed. Because women of child-bearing age and possibly pregnant could be involved in spraying, a separate comparison was made for reproductive effects. Only if one assumes little protective clothing, high dermal absorption rate, and high exposure would the worker dose exceed a very safe dose level as determined by dividing the reproductive effect NOEL by a safety factor of 100.

The analysis in Appendix B assumes that after oral doses of carbaryl a carcinogenic compound, N-nitrosocarbaryl, is formed in the stomach. The analysis estimates the probability of cancer from various worst-case doses using a cancer prediction model that overestimates risk. Even with assumptions of many worst-case doses to one individual during two successive spray projects, the individual's cancer risk is less than one chance in 100 million.

The linear cancer model used in the analysis has been shown to estimate the upper bound of the cancer risk. The calculated risks are below those associated with natural background radiation that humans encounter on a daily basis. A cancer risk on the order of one in a million is accepted by the Food and Drug Administration and EPA.

Accidents involving the spill of pesticides into water or onto land (and workers) are analyzed in Appendix B. The highest exposures could occur during worker involvement and cleanup of a spill on land. Although fatal doses would be unlikely workers could experience dizziness, nausea, headache, excessive perspiration, vomiting, cramping, difficulty breathing and skin rash. These symptoms could be reversed with medical treatment.

The probability of an accident resulting in a spill is calculated to be less than one chance in 18,000 each year given the extent of spraying possible in the entire Region. The probability of high human exposure resulting from such an accident cannot be calculated except to say that it would be less than the probability of a spill.

MITIGATING MEASURES

Procedures, guidelines, and other measures can be implemented to mitigate nontarget effects in suppression/protection projects that include the use of insecticides. During application, insecticide droplets can settle in nontarget areas. Potential impact in those areas as well as exposure to nontarget organisms, including humans, can be minimized by using the proper type of application equipment, proper calibration of this equipment, adherence to strict standards for site and insecticide selection, and by following the operational plan for the project, including the use of buffer strips where necessary. Licensed applicators will directly supervise the mixing, application and disposal of all insecticide containers used in this project to ensure compliance with registration requirements.

Public involvement in the selection of treatment areas and where appropriate, the identification of exclusion areas, and mitigating measures to be used. Through public involvement assists and notification, individuals known to be allergic to certain insecticides can be notified and appropriate measures can then be taken to avoid exposure to that insecticide. Notification of the public as to when the insecticide will be applied, will be by telephone, local newspaper, local radio, individual letter, and/or personal contact. Users of public recreation areas will be notified through posting of campgrounds at least 24 hours prior to treatment. Potential exposure to insecticides is greatest for individuals involved in the actual mixing and application. Proper protective clothing and safety procedures will minimize any risk to individuals involved in these tasks. Safety plans will provide for contingencies such as pesticide spills and worker exposure.

It is emphasized that this project proposal is for a ground application only and by its nature is target specific in contrast to aerially dispersed insecticide applications. No applications will be made within 50 feet of an above-ground water source (lake, river, or stream). This figure was arrived at based on research results (Haverty 1983) that report that carbaryl could not be detected at distances greater than 12 meters from an individually treated tree. In an effort to provide additional safeguards, all picnic benches, barbeque stoves, and other campground amenities will be covered with plastic sheeting during treatment. Warning signs will be placed on each treated tree giving the following information; date of treatment, material used, public official to be contacted for further information. Subject recreation sites will be signed and closed to public use for 10 days following treatment.

Insecticides will be applied only when weather conditions favor effective insecticide deposition. Most insecticide treatments are applied in the early morning (4:30 a.m. to 10:00 a.m.) and late afternoon-early evening hours (4:00 p.m. to 9:00 p.m.), as this is when atmospheric conditions generally are the most favorable for maximizing insecticide deposition in treatment areas. Occasionally insecticide application may continue throughout the day so long as conditions are favorable. To minimize drift, application of insecticide will be made only when wind speed does not exceed 3-4 MPH. Insecticide application will be suspended when rain is imminent. After rain, insecticide will be applied only when the tree bole is dry.

Monitoring Procedures

During insecticide application, spray deposit cards or a similar technique can be used to check deposition and drift. Daily weather measurements of temperature, wind speed, and relative humidity generally are made on site, and subsequent communication with weather stations to help ensure that insecticide application is made under the proper weather conditions.

Cards or other devices will be placed along water course to verify that water contamination does not occur. If such contamination is detected, spraying will cease until the problem is corrected.

PUBLIC NOTIFICATION AND INVOLVEMENT

In accordance with the NEPA process, the FS encourages public involvement in the development of individual tree protection projects.

The purpose of this public involvement process is to:

1. Explain the proposed action and its need.

2. Discuss the consequences (if any) of the proposed action.

3. Solicit identification of local issues and concerns or individuals particularly sensitive to the insecticides planned for use.

4. Stimulate discussion of alternative measures and their consequences.

Specific public participation and notification procedures relative to this project are listed below.

A Notice of Intent to prepare this Environmental Impact Statement for Protection on Individual Trees from Attack by Mountain Pine Beetle was published in the Federal Register on February 21, 1986. Newspaper articles outlining the proposal, the environmental impact statement process, and how to get additional information, or how to comment on the proposal were published in the adjacent communities in late February 1986 by the Montana Standard, Butte, Montana, Whitehall Ledger, Whitehall, Montana, and the Boulder Monitor, Boulder Montana. The Deerlodge

National Forest released a Draft Environmental Imapct Statement in mid March 1986 which was transmitted to all individuals, groups, and government agencies known or thought to be interested or affected by the proposal. The comment period for the Draft EIS was from March 21, 1986 to May 5, 1986.

Responses to the Draft EIS were received from two individuals (E. Carroll Speck and Rick Torre) and seven government agencies (USDA Soil Conservation Service, U.S. Department of Transportation, U. S. Department of Housing and Urban Development, U. S. Department of the Air Force, Montana State Intergovernmental Clearing House, the U. S. Environmental Protection Agency, and the Montana State Department of Agriculture). The actual responses are located in Appendix D. Mr. Speck opposed the use of insecticides to control mountain pine beetle in campgrounds because of the possible increase to soil and water pollution. Mr. Torre asked for further explanation on the extra polation of studies from animals to humans and the possibility of viral enhancement in association with the use of carbaryl. The Environmental Protection Agency pointed out the toxicity of carbaryl to bees, the need to be able to handle an accidental spill, the need to use individuals licensed for pesticide application during implementation, and the disposal of empty pesticide containers. The Montana Statement Department of Agriculture proposed the use of pheremore sex attractants as an alternative, the conversion from high risk lodgepole stands to lower risk vegetative types,identification of habitat types at each site, the use of integrated pest management practices, and questioned the possibility of increase fire hazard resulting from mountain pine beetle induced tree mortality. The other agencies that responded to the Draft EIS had no comment.

The concern for pontential soil and water pollution are appreciated by the Deerlodge National Forest and are discussed at length both in the EIS and Appendices A and B of the EIS. Human health risks associated with the use of carbaryl were often extrapolated from animal tests because relatively few of these tests have been conducted on human subjects. Extrapolation from animal test results is a common practice in human medical and health research studies. The risk of viral enhancenment from exposure to carbaryl, although small, was considered and is included in the Human Health Risk Analysis (Appendix B) of the EIS.

There is no domestic bee production or use within two miles of any of the proposed project areas and is therefore not expected to be impacted. Impact to wild bees is expected to be very limited and for short duration. The Deerlodge National Forest has a Forest Emergency and Natural Disaster Plan which identifies the procedure to follow in case of chemical spill. The use of certified pesticide applicators licensed in the State of Montana has been added on page 17 of the final EIS and included in the Record of Decision. The use of pheremone sex attractants can be used to move small populations of mountain pine beetles short distances. This technique has been in use around the three recreation sites for the past two years but has not prevented tree mortality from occurring within the recreation sites. As mountain pine beetle populations continue to build the effectiveness of this treatment will be further reduced. The conversion from high risk lodgepole pine to lower risk vegetative types is discussed on page 7 of the EIS under the "clearcut and replant" alternative. Habitat types have been added to the table on page 10 of the final EIS. These habitat types indicate that lodgepole pine is a seral stand component. Therefore, the use of integrated pest management practices to reduce mountain pine beetle losses is a long term objective at each recreation

site as well as throughout the Deerlodge National Forest. However, since these techniques deal primarily with changing species composition and age class distribution of the forest vegetation, they are of only limited use in the short term if the forested setting is to be maintained at each recreation site during the duration of the current mountain pine beetle outbreak. Fire hazard resulting from mortality of trees adjacent to the three recreation sites being analyzed is outside of the scope of this EIS. Under all alternatives, fire hazard will be increased in areas adjacent to the recreation sites for a time until trees killed by mountain pine beetle are removed and slash disposal completed or natural abatement of fuels resulting from mountain pine beetle mortality occurs. The cost of treating all susceptible trees adjacent to the recreation sites would be prohibitively expensive and was therefore not considered.

A list of agencies and individuals to whom copies ofthe Environmental Impact Statement are sent is included in Appendix E.

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GLOSSARY OF TERMS 1/

Acceptable Daily Intake (ADI): The maximum dose of a substance that is anticipated to be without lifetime risk to humans when taken daily.

Acetylcholine: A compound that is released at many autonomic nerve endings which acts in the transmission of the nerve impulses to excitable memebranes.

Acetylcholinesterase: An enzyme which inactivates acetylcholine, a compound which induces nerves to transmit an electrical signal and thereby controls certain nerve activity.

Active Ingredient AI: The effective part of a pesticide formulation, or the actual amount of the technical material present in the formulation.

Acute Toxicity: The toxicity of a compound when given in a single large dose or in multiple doses over a period of 24 hours or less.

Adenoma: A benign tumor of glandular origin and structure.

Adsorption: Adhesion of substances to the surfaces of solids or liquids; technically, the attraction of ions of compounds to the surfaces of solids or liquids.

AI: Abbreviation for active ingredient.

Amine: Any of a group of chemical substances formed by exchanging one, two, or three hydrogen atoms for one, two, or three hydrocarbon groups.

Amphipods: Any of a large group of small crustaceans with a laterally compressed body (e.g. beachhoppers, scud).

Anemia: A condition marked by significant decreases in hemoglobin concentration and in the number of circulating red blood cells. Also known as oligochromemia.

Anorexia: Loss of appetite.

Anticholinesterase: Any agent, such as a nerve gas, that inhibits the action of cholinesterase, and thereby destroys or interferes with nerve conduction.

1/ This glossary includes terms from the EIS and appendices.

Aromatic: A group of organic compounds based on a ring of six carbon molecules bonded with a unique type of hybrid bond known as a benzene bond. The basic aromatic compound is benzene (C_6H_6). Aromatics have unique chemical properties, including a tendency to have a noticeable aroma.

Arthropods: Major group of invertebrate animals belonging to the phylum Arthropoda. This group includes insects, spiders, and crustaceans.

Ataxia: Lack of muscular coordination due to any of several nervous system diseases.

Atrophy: Diminution in the size of a cell, tissue, or organ that was once fully developed and of normal size.

Benign Tumor: A nonmalignant tumor.

Bioaccumulation: The process of a plant or animal selectively taking in and storing a persistent substance. Over a period of time, a greater concentration of the substance is found within the organism than in the organism's environment.

Bioassay:

1. A method for quantitatively determining the concentration of a substance by its effect on the growth of a suitable animal, plant, or microorganism under controlled conditions.

2. The testing of the effects of chemical substances on live organisms under controlled conditions.

Bioconcentration: The process in which a pesticide becomes concentrated in plants or animals. The chemical increases in concentration at each succeeding link in the food chain.

Bioconcentration factor: A numerical value expressing the increase in concentration of a persistent substance between food chain levels, for example, the concentration of a persistent substance in the tissue of a cow may be three times that in the tissue of the grass the cow eats.

Biological Control: The use of natural enemies to attack a target plant, retard growth, prevent regrowth, or prevent seed formation.

Biological Half Life: The time required for half the amount of substance (such as an insecticide) in or introduced into a living system to be eliminated whether by excretion, metabolic decomposition, or other natural process.

Biosynthesis: Production by synthesis of chemical compound by a living organism.

Biotransformation: The process of altering a substance by reaction with metabolic processes or compounds in bacteria, plants, or animals.

Browse: That part of leaf and twig growth of shrubs, woody vines, and trees on which browsing animals can feed; to consume browse.

Buffer (Strip or Zone): A zone left untreated with herbicide (at the outer edge of a treated area or along streams) as protection against the effects of treatment.

Caddisfly: A small freshwater moth-like insect whose larvae live encased in self-constructed shells. Member of order Trichoptera.

Carbaryl: Carbamate insecticide; the active ingredient in insecticide formulations sold under the trademane Sevin.

Carcinogen: A substance producing or inciting cancer.

Carcinogenic: A substance producing or inciting cancer.

Carcinogenicity: Tendency of a substance to cause cancer.

Chemical Degradation: The breakdown of a chemical substance into simpler components through chemical reactions.

Chlorosis: A disease condition of green plants seen as yellowing of green parts of the plant.

Cholinesterase: See acetylcholinesterase.

Chronic Toxicity: The effect of a compound on test animals when exposed to sublethal amounts continually. Usually daily exposures over a period of time: weeks, months or years.

Collembola: Springtails. Primitive, wingless group of insects commonly found in soil and duff.

Colloid: See SOIL COLLOID.

Congestion: An abnormal accumulation of fluid, usually blood, but occasionally bile or mucus, within the vessels of an organ or part.

Conjugate: To become joined together.

Control: Reduction of a pest problem to a point where it causes no significant economic damage.

Copepods: Usually minute freshwater and marine crustaceans belonging to the order Copepoda.

Corixids: Group of aquatic insects, usually freshwater, that feed on algae and other minute aquatic organisms; belong to the family Corixidae.

Cornea (Corneal injury): The transparent anterior portion of the outer coat of the vertebrate eye covering the iris and the pupil.

Critical Habitat:

1. Specific areas within the habitat occupied by a species at the time it is listed under the Endangered Species Act where there are physical or biological features:

A. Essential to the conservation of the species.

B. That may require special management considerations or protection.

2. Specific areas outside the habitat occupied by the species at the time it is listed upon the determination by the Secretary of the Interior that such areas are essential for the conservation of the species.

Crucial Wildlife Habitat: An area of habitat essential to the survival of any wildlife species sometime during its life cycle.

Crustaceans: Large group of mostly aquatic arthropods belonging to the class crustacea and characterized by a chitinous or calcareous and chitinous exoskeleton. Members of this group include Copepods, water fleas, shrimps, and wood lice, among others.

Cultural Resources: Remains of human activity, occupation, or endeavor, reflected in districts, sites, structures, building, objects, artifacts, ruins, works of art, architecture, and natural features that were of importance in past human events. Cultural resources consist of:

1. Physical remains.

2. Areas where significant human events occurred, even though evidence of the events no longer remains.

3. The environment immediately surrounding the actual resource.

Degeneration: Deterioration of a tissue or an organ in which its function is diminished or its structure is impaired.

Degenerative: Relating to or tending to cause degeneration.

Degradation: Conversion of an organic compound to one containing a small number of carbon atoms.

DEIS: Draft Environmental Impact Statement.

Dermal: Pertaining to the dermis.

Dermis: The deep layer of skin, a dense connective tissue richly supplied with blood vessels, nerves, and sensory organs.

Detoxification: The act or process of removing a poison or the toxic properties of a substance in the body.

DNA (Deoxyribonucleic Acid): Any of the nucleic acids that are the molecular basis of heredity in many organisms.

Dosage: The regulation of doses: how often and for how long.

Dosage Rate: Quantity of a toxicant applied per unit area. Usually expressed as oz. or lbs. active ingredient per acre.

Dose: The amount of chemical administered at one time.

Drift: The movement of airborne pesticide particles by air motion or wind away from an intended target area.

EC50: Median effective concentration; it is the concentration (ppm or ppb) of the toxicant in the environment (usually water) which produces a designated effect on 50 percent of the test organisms exposed.

Ecological Niche: The physical space in a habitat occupied by an organism; its functional role in a community; and its position in environmental gradients of temperature, moisture, pH, soil, and other conditions of existence.

Edema: An excessive accumulation of fluid in the cells, tissue spaces, or body cavities due to a disturbance in the fluid exchange mechanism. Also know as dropsy.

EIS: Environmental Impact Statement.

Endangered Species: Plant or animal species that are in danger of extinction throughout all or a significant part of their range. See THREATENED SPECIES.

Engorge: To devour to the limit of capacity, thus, to swell up.

Environmental Analysis: Procedure defined by the National Environmental Policy Act of 1969 whereby the environmental impacts of a planned action (in this case gypsy moth suppression and eradication projects) are objectively reviewed.

Environmental Assessment (EA): A systematic environmental analysis of site-specific activities used to determine whether such activities would significantly affect the human environment and whether an environmental impact statement is required.

Environmental Impact Statement (EIS): An analytical document developed for use by decisionmakers to weigh the environmental consequences of a potential action.

EPA: U. S. Environmental Protection Agency.

Ephemeral Stream: A stream that flows only in direct response to precipitation, and whose channel is at all times above the water table.

Epidemiology, Epidemiological Studies: The comparative study of diseases or health characteristics in large human populations.

Epidermis: The outer nonsensitive, nonvascular portion of the skin comprising two strata of cells, the stratum corneum, and the stratum germinativum.

Epithelium (Epithelial Surface): A primary animal tissue, distinguished by cells being close together with little intercellular substance, covers free surfaces and lines body cavities and ducts.

Fetotoxic: Capable of producing adverse, though reversible, effects in a developing fetus.

Food Chain: A series of plant or animals species in a community, each of which is related to the next as a source of food.

Forage: All browse and herbaceous foods available to grazing animals. Forage may be grazed or harvested for feeding.

Forb: A low-growing herbaceous plant that is not a grass, sedge, or rush.

Formulation: The form in which a pesticide is packaged or prepared for use.

Frass: Insect solid excrement.

FS: Forest Service. The USDA agency responsible for forest insect suppression projects.

Gavage: The administration of nourishment through a stomach tube.

Habitat: The environment in which an organism occurs.

Half-life: The time required for half of a substance to be eliminated or disintegrated by natural processes.

Hectare: 10,000 square meters or about 2.47 acres.

Hemiptera: True bugs. Group of insects with semi-toughened forewings and sucking mouth parts.

Hemoglobin: The iron-containing, oxygen-carrying molecule of the red blood cells of vertebrates.

Herbaceous: Having little or no woody tissue, and usually persisting for a single season.

Herbicide: A substance used to inhibit or destroy plant growth. If its effectiveness is restricted to a specific plant or type of plant, it is called a selective herbicide. If it is effective for a broad range of plants, it is called nonselective.

Herbivore: An animal that exclusively eats plants.

Histopathology: A branch of pathology that deals with tissue changes associated with disease.

Humic: Relating to decomposition-resistant organic matter in soil.

Hydrolysis: Decomposition or alteration of a chemical substance by water.

Hymenoptera: A large order of insects comprised of the ants, bees, sawflies, and wasps. The typical adult has four membranuos wings and chewing type mouth parts.

Infiltration: The downward entry of water into the soil.

Instar: The term for an insect before each of the molts (shedding of its skin) it must go through in order to increase in size. Upon hatching from its egg, the insect is in instar I and is so called until it molts, when it begins instar II, etcetera.

Integrated Pest Management: Use of several techniques (for example, burning, grazing and mechanical, manual, or chemical methods) as one system to control animals or plants where they are unwanted.

Intermittent Stream: A stream that only flows at certain times of the year when it receives water from springs or from some surface source such as melting snow.

Interstitial: Situated within but not restricted to or characteristic of a particular organ or tissue.

Intestinal Mucosa: The mucous membrane of the tubular portion of the vertebrate digestive tract, usually between the stomach and the cloaca or anus.

Intraperitoneal, Intraperitoneally: Related to a structure or process occurring within the peritoneum, a membranous lining of the body cavity.

Invertebrate: Major group of animals of which arthropods are members; characterized by the lack of backbone and spinal column.

In Vitro: Outside the living body and in an artificial environment.

IPM: Integrated Pest Management.

K-Value: The ratio of the amount of pesticide absorbed on soil (ppm) to an equilibrium concentration of 1 ppm in water.

Label: All written, printed, or graphic matter on or attached to pesticide containers as required by law.

Larva (Plural Larvae): An insect in the earliest stage of development, after it has hatched and before it changes into pupa; a caterpillar, maggot, or grub.

LC50 (Lethal Concentration 50): Abbreviation denoting the lethal concentration or concentrations of toxicant necessary to kill 50 percent of the organisms being tested. It is usually used in testing of fish or other aquatic animals.

LD50 (Lethal Dose 50): The dose of a substance (expressed in milligrams of substance per kilogram of animal body weight) which is fatal to 50 percent of the test animals. Also known as median lethal dose.

Leaching: The movement of chemicals through soil by water or the movement of herbicides out of leaves, stems, or roots into the air or soil.

Lepidoptera: A large order of insects, including the butterflies and moths; characterized by four scale-covered wings and coiled sucking mouth parts.

Lesion: A structural or functional alteration due to injury or disease.

Lipid Soluble: Soluble in oils or fats, and generally insoluble in water.

Log Dosage Probit (LDP): A method of determining theoretical percent kills at any given dosage by plotting a series of actual dosages expressed in logarithmic units against percent kill expressed as probability units. By following along the straight line fitted to the points obtained from the actual doses, the relationship between any dosage and mortality can be determined.

Lowest Observable Adverse Effect Level (LOAEL): In a series of dose levels tested, it is the lowest level which an effect is observed.

Malignant Tumor: A growth or proliferation of growths which terminate in death if not checked by treatment.

Median Threshold Limits (TLM): Synonymous with the median tolerance limit (TL50), but expressed in a slightly different way, i.e. the concentration of a test material at which half of the test animals are able to survive under test conditions over a specified time.

Metabolism: The physical and chemical processes by which foodstuffs are synthesized into complex elements, complex substances are transformed into simple ones, and energy is made available for use by an organism.

Metabolite:

1. Any substance taking part in or produced by metabolism.

2. A compound derived in the case of a pesticide by chemical action upon the pesticide within a living organism (plant, insect, higher animal, etc.). The action varies (oxidation, reduction, etc.) and the metabolite may be either more toxic or less toxic than before. The same derivative may in some cases develop upon exposure of the pesticide outside a living organism.

Metamorphosis: The series of changes through which an insect passes in its growth from the egg through the larva and pupa to the adult; complete when the pupa is inactive and does not feed; incomplete (or simple) where there is no pupa and where the nymph is active and feeds.

mg/kg: Milligrams per kilogram; used to designate the amount of toxicant required per kilogram of body weight of test organisms to produce a designated effect; usually the amount necessary to kill 50 percent of the test animals. One mg/kg = 1 ppm. One mg = 0.000035 ounce, and 1 kg = 2.2 pounds.

mg/kg/day: Milligrams per kilogram of body weight per day.

Microbial Degradation: The breakdown by bacteria of chemical substances into simpler components.

Microbial Pathogen: Generally, a microorganism which causes disease in its host; more specifically, a term used in preference to microbial "insecticide" to denote a microorganism used by man to suppress insect pest populations.

Microgram (ug):

1. A unit of microscopic weight, one thousandth of a milligram. Represented by the symbol Mg.

2. One millionth of a gram.

Microliter: A unit of microscopic volume; one thousandth of a milliliter. Represented by the symbol ul.

Miscible:

1. Tendency of two or more liquids to form a uniform blend.

2. Mixes easily with water; a term applied to oils that have an agent added to the oil that makes it easy to dilute with water and remain as a mixture without separation for an extended time.

Miscible Liquids: Two or more liquids capable of being mixed in any proportion and remaining mixed under normal conditions.

Mode of Action: A term used to describe the way or method by which a pesticide may alter or adversely affect physiological or biochemical events in an organism resulting in a toxic effect, usually ending in death.

Mobility (Herbicide): The capability of a herbicide to be moved easily, vertically, or laterally, with the normal movement of water.

Molting Hormone: A hormone secreted by the prothoracic gland necessary for shedding skins in passing from one growth stage to another during immature development and growth of insect (Ecdysone).

Multiple Use: The harmonious use of land for more than one purpose, not necessarily the combination of uses that will yield the highest economic return.

Mutagen: A substance that tends to increase the frequency or extent of genetic mutations (changes in hereditary material).

Mutagenic Agent: A chemical agent that when applied to a living organism brings changes in the hereditary makeup of the individual resulting in progeny that differ from the parent in some respect.

Mutagenicity: The capacity of a substance to cause changes in genetic material.

National Ambient Air Quality Standards (NAAQS): The allowable concentrations of air pollutants in the air specified by the Federal Government in Title 40, Code of Federal Regulations, Part 50. The air quality standards are divided into primary standards (based on the air quality criteria and allowing an adequate margin of safety requisite to protect public health) and secondary standards (based on the air quality criteria and allowing an adequate margin of safety requisite to protect the public welfare from any unknown or expected adverse effects of air pollutants). Welfare includes effects on soils, water, crops, vegetation, manufactured materials, animals, wildlife, weather, visibility, and climate; damage to and deterioration of property; hazards to transportation; and effects on economic values and on personal comfort and well being.

National Register of Historic Places: The official list, established by the Historic Preservation Act of 1966, of the nation's cultural resources worthy of preservation. The Register lists archaeological, historic, and architectural properties (districts, sites, building, structures, and objects) nominated for their local, state, or national significance by state and federal agencies and approved by the National Register Staff. The Register is maintained by the National Park Service.

National Trails System: A network of nationally significant trails consisting of:

1. Scenic, extended trails that provide outdoor recreation opportunities and conserve nationally significant scenic, historic, natural, or cultural qualities of areas through which they pass.

2. Recreation trails that provide a variety of outdoor recreation uses in or reasonably near urban areas.

Necrosis: Death of tissue, plant or animal.

NEPA: National Environmental Policy Act of 1969, Public Law 91-190.

Neuropathy: An abnormal and usually degenerative state of the nervous system or nerves.

Nitroso: The radical NO- with trivalent nitrogen.

Nitrosoamines: A class of compounds, many of which are carcinogen. Often formed by the reaction of an amine and nitrite; see N-nitrosocarbaryl.

Nitrosocarbaryl: A compound formed by the reaction of a nitrite ion and a carbaryl molecule. The compound is assumed, in this analysis, to be a carcinogen.

NOEL: The No Observable Effect Level. In a series of dose levels tested, it is the highest level at which no effect is observed, i.e., safe in the species tested.

Non-Ionic: Substances which do not dissociate in water to form positive or negative ions.

Nonselective: A chemical that is generally toxic to plants or animals without regard to species. A nonselective insecticide may kill or harm beneficial insects.

Notonectids: Group of predaceous insects belonging to the family Notonectidae. Commonly called backswimmers.

Nucleic Acids: A group of biochemical substances composed of phosphoric acid, a sugar, and a nitrogenous base. Examples: DNA and RNA.

Oncology: The study of the causes, development, characteristics and treatment of tumors.

Oncogenic: The property to produce tumors (not necessarily cancerous) in tissues. See carcinogenic.

Oral Administration: A method of introducing toxicants into test subjects by forced feeding through the mouth with a blunt needled syringe or other mechanical means.

Oral Toxicity: Toxicity of a compound when given by mouth. Usually expressed as number of milligrams of chemical per kilogram of body weight of animal (white rat) when given orally in a single dose that kills 50 percent of the animals. The smaller the amount, the greater the toxicity.

Ossification: Process of forming bone.

Oxidation:

1. A reaction in which oxygen combines with another substance with the liberation of heat with an increase in positive valence of an element.

2. The removal of hydrogen from a compound.

3. Loss of electrons from an atom.

Parasite: Any animal that lives in, on, or at the expense of another.

Partitioning: Separation of chemical mixtures through utilizing solubility differences with two solvents that are immiscible (chloroform and water for example).

Parts Per Billion (ppb): An expression of quantity (usually weight) of chemical in or on food, plants, animals, etc. One part per billion equals 1 pound in 500,000 tons. Also used in testing when chemical is one part in one billion parts of the medium containing test organism.

Parts Per Million (ppm): In toxicological terminology, the expression of the ration by weight of toxicant to the weight of one million weight units of medium containing test organisms, or for plant or animal residues, the weight of toxicant to one million equivalent weight units of the plant.

Penetrant: Wetting agents that enhance the ability of a liquid to enter into pores of a substrate (to penetrate the surface) are termed penetrating agents or penetrants.

Penetration: In toxicological terms, the movement of a toxicant through the outer covering or an organism.

Permeability: As used in toxicology refers to the ability of chemicals to penetrate a physical barrier (e.g. tissue or cuticle).

Persistence: The quality of an insecticide to persist as an effective residue due to its low volatility and chemical stability, e.g. certain organochlorine insecticides.

Pesticide Tolerance: The amount of pesticide residue which may legally remain in or on a feed crop or in or on animal tissues. Federal residue tolerances are established by the Environmental Protection Agency.

pH Value: The degree of acidity or alkalinity. The pH scale of 0 to 14 expresses intensity of acidity or alkalinity in the same manner that degrees in the thermometer express intensity of heat. The pH value of 7.0, halfway between 0 and 14, is neutral neither acid nor alkaline. pH values below 7.0 indicate acidity with its intensity increasing as the numbers decrease. Conversely, pH values above 7.0 indicate alkalinity with its intensity increasing as the numbers increase.

Pharmacokinetics: The study of chemical reactions in human or animal systems.

Pheromone: An exocrine chemical messenger secretion produced by an organism, which influences or activates the behavior or physiology of other individuals of the same species. Some pheromones are highly potent insect sex attractants. For some species, laboratory-synthesized pheromones have been developed for trapping purposes. Examples: disparlure (pherocon GM), grandlure (pherocon BW), muscalure (muscamone), etc. cf. Hormone.

Photodecomposition: The process of light energy causing cleavage of chemical bonds within a compound, resulting in formation of two or more smaller, different compounds.

Photooxidation: The process occurring when light energy causes alteration of a chemical bond within a compound, resulting in either addition of an oxygen atom or loss of a hydrogen atom.

Phytotoxic: Poisonous or harmful to plants.

Plecoptera: Stone flies. Group of insects, the nymphs of which are aquatic and mostly phytophagous.

Poison: Any toxic substance that upsets normal physiological and biochemical mechanisms is a living organism by surface absorption, injection, or ingestion, eventually leading to death if the dosage is sufficiently strong.

Pollutant: A harmful chemical or waste material discharged into the water, soil, or atmosphere. An agent that makes something dirty or impure.

Potable Water: Water that is suitable for human consumption.

Potentiation: A term used to describe the enhanced toxicity attained by combining two or more chemicals and giving the combination more killing power than the sum of the individual toxicities. Used primarily in pharmacology.

ppb: Parts per billion; the number of parts of a substance in question per billion parts of a given material. One ppb = 1 ug/liter (water or air).

ppm: Parts per million; the number of parts of a substance in question per million parts of a given material. (1 ounce of salt in 62,500 lbs of sugar). One ppm = 1 mg/kg (on a weight basis) = 1 mg/liter (water or air).

Predator: An animal that preys on others.

Protectant: A chemical applied to the plant or animal surface in advance of the pest (or pathogen) to prevent infection or injury by the pest.

Proteins: A class of compounds comprised of complex combinations of amino acids (containing carbon, hydrogen, nitrogen, oxygen, and sometimes sulfur or phosphorous) and which are constituents of all living cells.

Pupa (Plural Pupae): The immobile, transformation stage in the development of an insect that, as an adult, is completely different in its appearance compared to what it looked like when it hatched from its egg. Examples include beetles, flies, moths, and wasps.

Rate: Refers to the amount of active ingredient/material applied to a unit area regardless of percentage of chemical in the carrier (dilution).

Residue: The quantity of actual toxicant deposited on a surface by any one of a number of methods of application (spray, aerosol, paint brush, dipping, etc.). Such a quantity remaining on or in a surface or crop (including livestock products) must not exceed legal limitations (regulated by EPA) at the time of harvest or when marketed. The value set is called the tolerance. See tolerance.

Resistance: Natural or genetic ability of an organism to tolerate the poisonous effects of a toxicant. It is a term used to express the failure of insecticide applications on populations of a species ordinarily susceptible to the compound. Strains resist the effects of the insecticide through avoidance "behavioristic resistance", or through physiological mechanisms.

Resorption: Absorption or less commonly, adsorption of materials by a body or system from which material was previously released.

Respiratory Toxicity: Intake of pesticides through air passages into the lungs. Pesticides may reach the lungs as a vapor or as extremely fine droplets or particles. Most compounds are more toxic by this route. Safety equipment is essential to protect the pesticide handler or applicator from the hazards of respiratory exposure whenever it is recommended on the label.

Risk: The probability that a substance will produce harm under specified conditions.

Route: The avenue of administration of a toxicant to test subjects; for example orally, topically, intraperitoneally, etc.

RPAR: Rebuttable Presumption Against Registration. EPA process for reviewing and subsequently approving or withdrawing registration of pesticides.

Runoff: The part of the precipitation in a drainage area that is discharged from the area in stream channels, including surface runoff, ground water runoff, and seepage.

Scoping Session or Activities: As defined under the National Environmental Policy Act - an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action. This may include public meetings whereby significant issues are identified, or may simply be letters of inquiry to interested agencies, groups, or individuals.

Selective Insecticide: One which kills selected insects, but spares many or most of the other organisms, including beneficial species, either through differential toxic action or the manner in which insecticide is used (formulation, dosage, timing, placement, etc.).

Senescence: Process or state of growing old.

Sensitivity: Susceptible to effects of toxicant at low dosage, not capable of withstanding effects, for example, many broadleaved plants are sensitive to 2,4-D.

Sevin 4 Oil^{R}: Commercial insecticide formulation containing the active ingredient carbaryl.

Sevin 80 S^{R}, Sevin Sprayable^{R}, Sevin XLR^{R}: See Sevin 4 Oil.

Solubility: An expression of the degree to which compounds dissolve in solvents.

Solution: Mixture of one or more substances in another in which all the ingredients are truly and completely dissolved in the molecular state. Example: sugar in water.

Solvent: A liquid that will dissolve a substance, forming a true solution (liquid in molecular dispersion). As applicable to insect toxicology, any liquid in which an insecticide will dissolve or be taken up.

Sorption: The process of taking up or holding by either absorption or adsorption.

Species Specificity: An insecticide that has a limited range of toxicity is said to exhibit species specificity. Synthetic organic insecticides sometimes show wide variation in toxicity to closely related groups. Some compounds have been developed as strict acaricides with high toxicity to mites, but with little or no action against insects.

Spermatocyte: A cell of the last or next to the last generation of male germ cells which differentiates to form spermatozoa.

Stomach Poison: A designation for toxicants that produce lethal effects primarily by ingestion into the stomach. Some of the older insecticides such as arsenicals produced mortality only upon being ingested, and exhibited little or no contact toxicity. Modern insecticides frequently exhibit both contact and stomach poison properties.

Sub-Lethal: In terms of dosage levels with toxicants, the highest level administered to test organisms without producing symptoms of poisoning.

Supplement: Same as adjuvant, substance added to a pesticide to improve its physical or chemical properties. May be a sticker, spreader, wetting agent, safener, etc., but usually is not a diluent.

Suppression Projects: Projects administerd by USDA Forest Service in cooperation with State or Federal agencies; designed to relieve high gypsy moth populations in high-value/high-use areas, or to prevent tree mortality in forested areas. Also includes comparable projects on National Forest System lands.

Surfactant: Ingredient which aids or enhances the surface-modifying properties of a pesticide formulation (wetting agent, emulsifier, or spreader).

Susceptible Species: A plant or animal that is affected by moderate amounts of a pesticide.

Suspension: A system of finely divided solid particles dispersed in a liquid, solid, or gas; for example a wettable powder in water.

Synapse: The point of contact between the axon of one neuron and the cell body or dendrites of another nerve fiber endings were biochemical reactions occur in nerve transmission.

Synergism: The effect produced by two chemicals applied jointly where the total response is greater than the sum of their independent effects.

Systemic Pesticides: A group of compounds capable of being absorbed by plants into the plant sap, or by animals into the blood stream without undue harm to the plant or animal, but capable of rendering high toxicity to arthropods feeding on the plant juice or animal blood. For example, a systemic insecticide can be applied to the soil, enter the roots of the plant, travel to the leaves,and kill insects feeding on the leaves. Examples: phorate, disulfoton.

Systemic Toxicity: Toxic effects that occur within an organism at other than the site of application.

Tachinidae: Family of flies, the larvae of which are parasitic.

Technical Pesticide: The form of the chemical as it is synthesized in its pure form by the manufacturer. It is rarely applied in this form, but is utilized to make concentrates from which ready-to-use material can be formulated.

Teratogenic: Substance that causes physical birth defects in the offspring following exposure of the pregnant female (mother).

Teratogenicity: The capacity of a substance to cause anatomical, physiological, or behavioral defects in animals exposed during embryonic development.

Threatened Species: Plant or animal species that are not in danger of extinction but are likely to become so within the foreseeable future throughout all or a significant portion of their range. See ENDANGERED SPECIES.

Threshold: The point at which a physiological or toxicological effect begins to be produced by the smallest degree of stimulation. Threshold limit refers to the maximum concentration of a chemical at which a health worker may be exposed for an 8-hour work day, day after day, without harmful effects.

Tissue Burden: The cumulative effects of a substance on a particular tissue.

Tolerance: The relation of the magnitude of pesticide residues to standardized allowable amounts on foodstuffs. By law, a regulation that establishes the maximum amount of a pesticide chemical that may remain on the raw agricultural commodity. Expressed as parts per million (ppm).

Tolerant: Capable of withstanding effects.

Toxic: Poisonous to living organisms.

Toxicity: The natural capacity of a substance to produce injury. Toxicity is measured by oral, dermal, and inhalation studies on test animals; injection may be used in insect studies.

Toxicology: The science (branch of physiology) devoted to the study of chemical substances which exert deleterious effects on living organisms; their chemistry in relation to their mode of action, antidotes, and physiological effects.

Translocation: In toxicological terms, the movement of a toxicant from a given part of an animal or plant to a different part of the organism. Application could be to the organism or to the soil in which the roots of the plant are growing.

Treatment: The application of chemicals to organisms for purposes of control or determining the efficacy of various compounds in experimental work.

Trichlorfon: Active ingredient found in chemical insecticide formulations sold under the trade name Dylox®.

USDA: United States Department of Agriculture.

USDI: United States Department of Interior.

Vapor Pressure: The property which causes a chemical compound to evaporate. The higher the vapor pressure, the more volatile is the compound. Vapor pressure is also a function of temperature. Commonly expressed in pressures of mm Hg at 25C or other selected temperature.

Vector: An organism such as an insect, which carries and transmits a pathogen to a plant or animal; for example, some virus diseases of plants can only be carried by certain insects.

Viral Enhancement: The increase in the potency of a virus through the action of an exogenous chemical.

Viscosity: Refers to the resistance in a fluid to the motion of its molecules among themselves; the thicker and heavier the fluid, the more viscous. It is a property of liquids that determine whether they flow readily or resist flow. Viscosity of liquids increase with a decrease in temperature.

Volatile: A compound is said to be volatile when it evaporates (changes from liquid or solid to a gas) at ordinary temperature upon exposure to air.

Volatility: Refers to the ease with which a substance changes from the liquid or solid phase to the gas phase. Highly volatile substances readily change form liquid to gas.

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APPENDIX A

LITERATURE REVIEW OF THE NONTARGET EFFECTS OF CARBARYL

LITERATURE REVIEW OF THE NONTARGET EFFECTS OF CARBARYL

This appendix is based in large on the material presented in the "USDA Forest Service Western Budworm Environmental Assessment, Shasta-Trinity National Forest, in cooperation with Champion International Corp., California, Department of Forestry, Southern Pacific Land Co., and the USDI Bureau of Land Management," 1984. It must be noted that much of the research cited is a result of nontarget organism studies conducted in conjunction with large-scale aerial application projects and in some cases, especially aquatic impacts, represent worst-case scenarios.

CARBARYL

Since it was developed in 1956, carbaryl has become one of the most widely used insecticides. About 25 million pounds were used in the U.S. in 1974 (Dolinger and Fitch undated). Most of it was used in agriculture, but about 3.75 million pounds were used around houses and in gardens. Such widespread use has prompted considerable investigation into effects which are now better understood than for most insecticides.

As with any man-made chemical pesticide, carbaryl has some degree of impact on the environment. However, during the years of research and practical use in spray programs against the gypsy moth, spruce budworm, and other pests, no significant adverse effects against vertebrates--including mammals, birds, reptiles, amphibians, and fish--have been reported.

Carbaryl was under review by the Environmental Protection Agency (EPA) for more than 4 years for possible RPAR (Rebuttable Presumption Against Registration) action. Rebuttable Presumption Against Registration is the process by which a material already on the market is subjected to intensive scientific review and public comment. Following a review, the EPA must decide whether to allow continued use of the material, limit the uses allowed, or remove it from the market. In 1980, the EPA announced that carbaryl will not be placed in RPAR status. The announcement included the following statement: "The Agency has concluded that the overall weight of evidence of the extensive data which are currently available does not indicate that risk criteria warranting a Rebuttable Presumption Against Registration for carbaryl have been met or exceeded" (Johnson 1980).

LIFE OF CARBARYL IN THE ENVIRONMENT

Carbaryl is effective against members of most insect orders (Haynes et al. 1957; Barrett 1968). The residue of carbaryl has an effective insecticidal property for several days after spraying. In one study, most saddled prominent larvae (moths) were killed within 48 hours of an application. However, larvae continued to be killed 8 days after spraying (Grimble et al. 1970). Skoog (1971) reported carbaryl effective at 18 days after treatment of grasshoppers. Residues of carbaryl applied at 1.0 pound per acre as Sevin 4 Oil remained high causing 63 percent and 77 percent mortality in two groups of laboratory-reared gypsy moth larvae fed leaves from trees in a suppression area at least 60 days after treatment. At 114 days, mortality from the residues was 5 percent and 11 percent (Doane and Schaefer 1971).

Insecticide residues are degraded and diluted in the environment by a number of physical factors. Rain is a major factor in reducing carbaryl residues (Union Carbide 1968a). In Massachusetts, rain in excess of 1.8 inches occurred 12 to 24 hours after spraying with Sevin Sprayable and the original 190 parts per million (ppm) residue of carbaryl or its degradations product on dominant scrub oak foliage was reduced to about 15 ppm 3 days after spraying (Wells 1966). Chemical decomposition on plants is less important and plants absorb only small amounts (Union Carbide 1976). Once carbaryl is in soil or water, however, chemical decomposition is dominant and promptly leads to less toxic degradation products.

"Half-lives" are a poor means of comparing persistence because they vary according to the conditions of pesticide application. They are used here for only quick generalized comparisons. The half-life of carbaryl residues is 3 to 4 days on plant foliage (McEwen and Stephenson 1979) . Carbaryl, in a Sevin 4 Oil formulation, was found to have a half-life of 8 to 10 days on range grasses (Fairchild 1970). On forest foliage treated for gypsy moth control, typical initial residues after treatment ranged from 30 to 100 ppm when carbaryl was applied for gypsy moth control. These declined to 5 to 20 ppm in 2 to 3 weeks (Beck 1971). Carbaryl (Sevin 4 Oil) applied at a rate of 1.0 pound active ingredient per acre on maple trees in Michigan, yielded residues of 500 ppm the day after spraying, 116 ppm after 8 days, 130 ppm after 15 days, and 43 ppm after 35 days (Fairchild 1970). In New York, the same treatment applied to two mixed oak stands yielded 192 and 55 ppm the day of spraying to 112 and 15 ppm 25 days after spraying (Fairchild 1970). Forest foliage sampling may reveal excessively high or low residues, in contrast to variation on row crops. This is believed to be due chiefly to the varied terrain and air currents likely found over large forested areas in contrast to agricultural cropland. Regardless of initial deposit the rate of residue loss is usually constant.

The reduction of carbaryl in sandy loam soil, after surface spraying with Sevin 50W and subsequent incorporation in the soil by rototilling, can be seen as follows (Union Carbide 1968b):

Persistence of Sevin 50W[1] insecticide in the upper 6 inches of soil

Carbaryl/acre (lbs)	0 days (ppm)	8 days (ppm)	17 days (ppm)	31 days (ppm)
3	1.1	0.6	0.2	0.3
9	3.4	1.9	1.1	0.3
27	10.5	5.6	2.7	0.3

[1]Sevin 50W is a 50 percent wettable powder formulation that is registered for ground application against certain fruit and ornamental tree insects.

In a monitoring study of a gypsy moth suppression project employing Sevin 4 Oil applied at 1.0 pound of carbaryl per acre, exposed soil residues dropped below the detection limit (0.2 ppm) 128 days after spraying; the last samples showing residues had been taken at 64 days. Occasional forest litter samples at 128 days still had slight residues (up to 0.65 ppm), but for most, residues had dropped below the limits of detection (Willcox 1972).

If carbaryl is applied unintentionally over open water, such as small brooks or ponds, an initital deposit of 1 ppm or less in water depth of about 4 inches may be expected to completely degrade or disappear in 1 or 2 days (Romine and Bussian 1971; California Department of Fish and Game 1963; Lichtenstein et al. 1966). Results looked similar for water treated with Sevin 4 Oil during a gypsy moth suppression project (Willcox 1972). Proportionately lower concentrations would occur in deeper water. It may help to relate this deposit concentration to potential hazard by pointing out that many raw foods carry residue tolerances of 10 ppm carbaryl and that more than 1 ppm in water is required to reach a 96-hour LD (lethal dose) value for fish. In one gypsy moth study, water residues of 30 parts per billion (ppb) dropped to 1.5 ppb in 1 day (USDA 1964).

Karinen et al. (1967) concluded that carbaryl reaching shallow mud flats in marine ecosystems would probably be rapidly removed from water by adsorption on bottom mud. Chemical degradation would then occur with carbaryl and 1-naphthol likely to persist in mud for 2 to 6 weeks. Carbaryl, as an 80 percent wettable powder, was applied at 10 pounds per acre to a mud flat at low tide, simulating application for oyster pest control. The initial residue (10.7 ppm) dropped rapidly the first day when the tide removed carbaryl and 1-naphthol not adsorbed on mud. The toxicant in the top inch of mud declined from 3.8 ppm to 0.1 ppm 42 days later.

Carbaryl decomposes or is metabolized to several subtances, of which 1-naphthol and 1-hathtyl (hydroxymethyl) carbamates are the most important (Union Carbide 1969). The relative toxicities, acute oral LD_{50} in rats (amount necessary to kill half the animals in a test population) of these metabolites are: 1-naphthol, 2,590 mg/kg and 1-naphtyl (hydroxymethyl) carbamate, more than 5,000 mg/kg. The no-ill-effect levels over a 7-day period for carbaryl, 1-naphthol and 1-naphthyl carbamates, are 125 to 250 mg/kg, 500 to 1,000 mg/kg, and 250 to 500 mg/kg, respectively.

Because of the rapid degradation of carbaryl to less harmful metabolites in the air, on vegetation, in the soil, and in water bodies, it is highly unlikely that repeated spray applications would cause a buildup of the chemical in the environment. For this reason no cumulative impacts are expected from repeated carbaryl applications.

EFFECTS ON OTHER MAMMALS

When fed to mammals, carbaryl is rapidly metabolized and is not stored in the tissue. There is no evidence of substantial effects on mammalian populations resulting from 1-pound-of-carbaryl-per-acre applications. Johnson (1971) indicates that deer, though 6 to 10 times more sensitive than bird species, showed no acute effects from normal application levels.

Small mammals were not adversely affected in total numbers during a study by Barrett (1968), in which he applied 2 pounds of carbaryl per acre. While some mammals, such as cotton rats, have been shown to respond with reduced reproductive rates, the niches were filled by other species. Other extensive studies (McEwen et al. 1962; USDA 1964) have failed to show any detrimental effects on small mammal populations. Connor (1960) reported that in a test area treated with a single application of carbaryl at 1 pound active ingredient per acre, the abundance of small mammals, as well as their condition and reproduction of young, seemed unaffected. In a study reported by Willcox (1972) on Peromyscus leucopus, the white-footed deermouse, there were no significant effects on reproductive condition and dispersion. Direct mortality was not observed and probably did not occur because total adult catches were similar in treated and check areas. Similar results were also reported by May (1978).

EFFECTS ON BIRDS

No direct adverse effects are expected to occur in bird populations within proposed treatment areas. Johnson (1971) indicated that exposing birds to low concentrations gives little cause for concern. Acute toxicity levels far exceed normal application rates such as 1 pound per acre. The oral LD_{50} for each of several bird species tested very high, usually around 5,000 ppm; thus, outright mortality of birds from field exposure to carbaryl is quite unlikely (Heath et al. 1972).

The conclusions are supported by feeding trials conducted on two species of birds,quail and pheasant. Large amounts of carbaryl in their diets did cause chronic poisoning symptoms in quail - 2,500 ppm in one test and 370/mg/kg/day for 84 days in another test. The average lethal dose was about 9,250 mg/kg. Reproduction was reduced when quail had ingested a total of 12,000 mg/kg at the rate of 250 mg/kg/day. Pheasants appeared more resistant than quail to carbaryl; more than 40 percent of the young birds survived after ingesting over 100,000 mg/kg during a 100-day test. Reproduction was reduced approximately 50 percent by inclusion of 500 or more ppm of carbaryl fed before or during the breeding season (DeWitt and Menzie 1971).

Although depressed brain acetylcholinesterase activity of forest birds was reported following application of 1.0 lb carbaryl/acre in Montana (Zinkl et al. 1977), treatments (0.31 and 0.69 lb carbaryl/acre) in Maine revealed no depression (Gramlich 1979). Observations by Connor (1960) on 49 species of birds exposed to carbaryl failed to reveal any adverse effects on their behavior, conditions, reproduction and rearing of young.

Studies of bird breeding responses to an aerial spray of carbaryl in Montana and Oregon reported no significant effects on the numbers of breeding birds, nest success, mortality rates, or the activities of brain cholinesterase (DeWeese et al. 1979; Richmond et al. 1979; Zinkl et al. 1979).

Two aerial applications totaling 2.0 lb carbaryl/acre in New Jersey resulted in a gradual decline in numbers and diversity of songbird communities (Moulding 1972). These effects persisted through the following year.

Extensive monitoring studies (Connor 1960; McEwen et al. 1962; USDA 1964; Stitt 1966) have failed to detect any adverse effects on bird populations after spraying with carbaryl. However, Bednarek and Davidson (1966) reported five young birds dead in a single nest 2 to 3 weeks after spraying. Bednarek and Davidson (1966) presumed that the young birds were exposed to the insecticide via the insects (food) brought back to the nest by parents. There was no confirmatory analysis to determine if death was caused by insecticide ingestion. Careful monitoring for the 1972 gypsy moth suppression operation in Pennsylvania was conducted by USDI Bureau of Sport Fisheries and Wildlife personnel; carbaryl applied as Sevin 4 Oil produced no evident harm to birds (Studholme 1972).

Excessive levels of carbaryl (70 to 600 ppm in the diet for 3 weeks) administered to roosters and laying hens in a laboratory study caused embryonic and check defects (Ghadiri et al. 1967). Carbaryl has been evaluated, registered, and is now in general use for control of lice, mites, and fleas on chickens, geese, game birds, pigeons, and turkeys. Egg production, hatchability, chick survival, and growth are unaffected by carbaryl when used as directed for these purposes. These applications to domestic birds result in considerably greater exposures to the pesticide than wild birds are expected to encounter when a forest is sprayed for insect control (Union Carbide 1970).

An indirect effect of carbaryl spraying on birds may be a depletion of available food which alters bird activity (Doane and Schaefer 1971). The investigators felt that nestlings may be particularly affected by a reduction in food supplies in large spray blocks. This relationship was further investigated by the Lake Ontario Environmental Laboratory (LOTEL) in a gypsy moth spray area in New Jersey. Nestling weights of blue jays, mourning doves, robins, barn swallows, and phoebes were monitored as an indicator of how much food was brought to the nest by adults. There was some evidence suggesting a connection between the spray and erratic weight patterns in two young robins in one nest. The authors stated that "it is difficult to be certain that this is a treatment effect..." (Willcox 1972). The phoebe and barn swallow, both almost completely insectivorous, did not seem to suffer any adverse effects. Observations showed no direct mortality in nestlings in the portions of the test area studied. The LOTEL report concluded "Nestling weight loss was negligible, if present at all. Thus no drastic food shortage resulted from the treatment" (Willcox 1972). A study by Moulding (1972) on the impact of carbaryl on forest birds revealed a decrease in bird populations after spraying and in the following year. He believed this was caused by a decreased food supply that resulted in some combination of opportunistic feeding outside the spray area, possible reduced reproductive success, and a shift in nest-site loyalty in some portions of the avian community.

EFFECTS ON NONTARGET INSECTS AND ARTHROPODS

The hazard of carbaryl to an insect population depends on the inherent susceptibility of that species, as well as the magnitude and duration of exposure to the insecticide. Application of carbaryl to prevent attack by the mountain pine beetle may affect some beneficial insects, but these effects should be transitory.

Other studies have investigated the effects of carbaryl on natural enemies of the gypsy moth. One study revealed that application of 1.0 pound of carbaryl per acre in a Sevin 4 Oil formulation did not affect sarcophogid and tachinid flies. Some reports have been made on the effects of carbaryl on natural enemies of the western spruce budworm. One study showed that parasitism was significantly higher (31.9 percent) in Sevin 4 Oil-treated plots during the 14-day postspray period than in the untreated areas. Percent parasitism by Glypta fumeriferanae decreased in sprayed areas, but parasitism by other species increased.

Twenty days after treatment, however, Sevin 4 Oil residues were still highly toxic to Calosoma beetles (Doane and Schafer 1971). Susceptibility of those predaceous beetles to carbaryl was noted in New York when Sevin Sprayable was applied to suppress another forest insect, the saddled prominent Heterocampa guttivitta (Grimble et al. 1970). After carbaryl application for gypsy moth suppression in a New York area in 1971, a study on the effects of parasites showed that they were not eliminated from the plots (Karpel 1973). Tachnid parasitism as measured on Ooencyrtus kuwanai was observed in all plots, but Apantales pupae were not seen.

Hardwood forests treated with carbaryl to control the gypsy moth showed reduction of ground beetle (Carabids) populations in Connecticut (Doane and Schaefer 1971) and New York (Dean et al. 1976). In Maine, as a result of carbaryl exposure, carabid populations were reduced by half for most of the summer (Hydorn 1979).

Some indications of carbaryl's effects on nontarget insects can be gained from Table 5 prepared by Lilly and Downey (1961). Comparison of results from the three tested areas show that carbaryl did not cause a major disruption of the insect community when a census was taken.

Table 5.--Comparison of nontarget insect numbers after treatments with carbaryl, DDT, and control (Lilly and Downey 1961).

Species	Area and Treatment: Amherst (unsprayed)	Mt. Toby (carbaryl)	Cadwell (DDT)
Caripeta angustiorata Wlk. A measuring worm	150	251	49
Estigmene congrua Wlk. A tiger moth	359	256	157
Prochoerodes traversata Dur. A measuring worm	235	210	41
Nadata gibbosa A&S A prominent	252	154	58
Phyllophaga spp. June beetles	337	148	65
Diplotaxis spp. Small scarab beetles	425	590	20
Scudderia septentrionalis A bush katydid	143	12	2
Ophioninae An ichneumon wasp	260	52	96
TOTALS	2,161	1,673	48

Nontarget forest insects and mites were studied in conjunction with a suppression project in New Jersey (Moulding 1972). An aqueous suspension of 1.0 pound of carbaryl per acre was used. Insect biomass, measured by light traps, was not affected. Moth numbers and biomass were also not demonstrably changed. Beetles as a group were unaffected in numbers and biomass. Nevertheless, June beetles (Phyllophaga spp.) and fish-flies (Neuroptera: Corydalidae) were severely reduced. Too few wasps were present for analysis. Soil collembola declined but recovered quickly, while soil mites were unaffected. The results suggested that forest arthropods inhabiting the upper forest strata received a greater impact from the insecticide.

The adverse effects of carbaryl on honeybees has been documented by several researchers (Anderson and Atkins 1958; Anderson 1964; Arrand and Corner 1960; Anderson et al. 1962; Moffett et al. 1970). Johansen (1959) reported carbaryl as highly toxic to honeybees. Adverse effects of carbaryl exposure are (1) heavy bee mortality, (2) reduced pollen and honey collections, (3) queenlessness, and (4) colony decline and frequent failure of overwintering colonies (Anderson 1964).

Native bees, the most important pollinators in Maine, when exposed to a 0.75 lb carbaryl/acre application in one area, suffered at least 50 percent population mortality (Miliczky and Osgood 1979).

The relationship of wild bee mortality to pollination success and fruit yield is not clearly understood. Fruit set of the insect-pollinated withe-rod (Viburnum cassanoides (L.)) was reduced by 80 percent in sprayed areas. The effect of decreased fruit production from insect-pollinated plants on small mammal and bird populations is not known. The long-term impact on wild bee populations is not clear. Vastly improved fruit set of withe-rod the year after treatment was caused by (1) better weather during the 1978 bloom, and (2) pollinator population recovery (Miliczky and Osgood 1979).

Economic losses can be avoided by moving hives prior to spraying and allowing 1 week before relocation (Strang et al. 1968). Covering hives prior to treatment can also reduces losses.

Spider mites are not susceptible to carbaryl (Haynes et al. 1957), but certain other arachnids, such as ticks (Drummond 1962), certain mites and spiders are susceptible in varying degrees. In a carbaryl treatment in Maine, both arboreal and terrestrial spider populations were reduced by nearly half (Hydorn 1979). In one study, phytophagous insects (Orders Homoptera and Hemiptera), dominant at the time of spraying were more severely affected than were predaceous insects and spiders; densities of the latter returned to normal levels within 3 weeks (Barrett 1968).

Two applications of 1.0 lb carbaryl/acre applied to a millet field resulted in significantly decreased soil litter decomposition (Barrett 1968). Total arthropod biomass and numbers were reduced 95 percent. Total arthropod biomass recovered to control levels after 5 weeks, but numbers of arthropods remained suppressed. Three weeks after a 2.0 lb carbaryl/acre (formulated as a wettable powder) application, earthworm populations were reduced 60 percent in pasture samples (Thompson 1971).

Application of 1.25 pounds of Sevin per acre (85 percent active ingredient mixed with fuel oil) showed no significant effect upon soil mite populations (Stegeman 1964). Larger application rates caused greater initial mite reduction and greater rates of increase in late summer. Application rates of 50 pounds per acre did not eliminate the mite populations. In the same study, Collembola populations were reduced by treatments ranging from 1.25 to 50 pounds of carbaryl per acre. The author concluded that 1.25 pounds per acre would not influence mites in forest soil, and while some effect on Collembola may be expected, it should be of short duration. Collembola and mites in New Jersey forest soil were exposed to carbaryl in aqueous suspension applied by aircraft at 1 pound per acre. The density of mite populations did not change. Collembola populations declined 3 weeks after treatment and recovered 3 weeks later (Moulding 1972).

The impact on nontarget insects and spiders will be minimized by using the lowest dosage rate (i.e., 1%) of carbaryl that will be effected.

EFFECTS ON PLANTS

Although carbaryl is not expected to cause damage to the foliage of trees, residues are expected to be present for several weeks. Seventy-eight days after Sevin 4 Oil was applied at 1 pound carbaryl per acre for gypsy moth suppression in New York, residues in leaves averaged 1.5 ppm. Sevin Sprayable, applied at the same carbaryl dosage rate, resulted in leaf residues averaging 1.4 ppm after 80 days (Devine 1971).

Carbaryl is not expected to have phytotoxic effects in the sprayed areas, other than what might result from inadvertent deposit on a few sensitive plants. Carbaryl applied to tender foliage may cause injury in the presence of rain or several days of high humidity after spraying (Union Carbide 1962 and 1968a).

EFFECTS ON AQUATIC ORGANISMS

Treatment areas, will be at least 50 feet from surface water. Thus, very little, if any, carbaryl will get into streams or lakes. The significance that small amounts of carbaryl have on aquatic organisms is considered in the following pages for fish, invertebrates, and plants.

Fish

Test results on fish must be interpreted carefully because all the conditions present during a test will not be found in the treatment areas and conditions were not standardized in the many reports of tests. Several chemical, environmental, and physical conditions such as water quality, water temperature, and fish body weight, or age, etc. play major roles in determining the acute toxicity of any toxicant to a particular fish species. One test illustrating this showed that carbaryl is more toxic to brown trout in alkaline water than in soft, acid water (Burdick et al. 1965). The test results discussed below present toxicity information for carbaryl in laboratory conditions and comparison with other insecticides.

The toxicity of carbaryl for three species of trout exposed to technical grade 99.5 percent carbaryl was: coho salmon (96-hour LC_{50} lethal concentration = 0.434 ppm), brown trout (LC = .63 ppm), and rainbow trout (LC = 1.95 ppm, Johnson and Finley 1980). The toxic level of carbaryl for fingerling brown trout was set at 1.5 ppm (Burdick et al. 1965). Application of carbaryl at 1 pound per acre directly over open water 1 foot deep would deliver approximately 0.4 ppm, a concentration that might possibly cause some fish mortality. Compared to its toxicity to cutthroat trout, carbaryl was twice as toxic to brook trout, 1.7 times as toxic to coho salmon, and 1.5 times as toxic to rainbow trout (Post and Schroeder 1971). Carbaryl proved more toxic to fingerling brown trout than its oil formulation suspension (Burdick et al. 1965).

Compared with other insecticides, carbamates (carbaryl 99 percent technical and Zectran 95 percent technical) were less toxic than organochlorines and organophosphates to the 12 species of fish (representing five families) tested (Macek and McAllister 1969). Compared to DDT, endrin and malathion, carbaryl exhibited the lowest toxicity to the four species of fish tested--brook trout, coho salmon, cutthroat trout, and rainbow trout (Post and Schroeder 1971).

A farm pond sprayed with Sevin 80 Sprayable (a water formulation) had no detectable carbaryl in the water 2 days after it had been sprayed at a rate of 6 pounds of carbaryl per acre. The detection method sensitivity was 0.02 ppm. Residue immediately after spraying was 4.8 ppm. There was no evidence of any effect on aquatic organisms. Residues in bottom mud disappeared after 4 days (Romine and Bussian 1971).

Gypsy moth suppression projects were monitored intensively in 1964 in New Jersey and Pennsylvania, and in 1966 in Massachusetts. In the New Jersey and Pennsylvania monitoring work, no fish mortality was observed in the treated area among any of the resident or introduced fish species which included brook, brown and rainbow trout. The conclusion was that spraying did not produce conditions in the treated streams which were detrimental to fish (USDA 1964).

The conclusion reached in Massachusetts was that carbaryl had no immediate or long-term effect on fish populations in the ponds treated during the operation. Laboratory tests showed that fish excreted as much as 97 percent of ingested carbaryl in 8 hours (Tompkins 1966). In his report Tompkins stated "No fish mortalities could possibly occur under normal operating conditions, and the investigator does not feel that further monitoring of this pesticide is necessary."

In a recent study on the impact of Sevin 4 Oil on the aquatic ecosystem during gypsy moth suppression in New Jersey, there was no apparent adverse effect on impounded trout or pickerel unintentionally receiving three applications of carbaryl. Also, no adverse effect was observed in green sunfish spawning, nesting behavior, or hatchability as a result of the triple application (Willcox 1972). In two streams deliberately treated with the same insecticide for a USDI study during gypsy moth spraying in Pennsylvania, no harm was observed in the fish under observation--brown trout (Pillow 1973)

In New Mexico on a western spruce budworm suppression project, fingerling rainbow trout in minnow cages placed in a stream sprayed with Sevin 4 Oil at 1.0 pounds of carbaryl per acre showed no sign of toxic effects (Parker et al. 1978).

During operational spraying in Maine (1.0 lb carbaryl/acre) acetylcholinesterase depressions averaged 20 percent for brook trout and 35 percent for Atlantic salmon (Hulbert 1978). These depressions were detected within 24 hours of spraying and persisted throughout the sampling period (192 hours). During spruce budworm spraying in Maine (1.0 lb carbaryl/acre) in 1975, brook trout depressions ranged between 13 and 22 percent and returned to normal within 48 hours. Activity depressions in Atlantic salmon were more gradual (9-27 percent) and failed to return to normal within the same sample period (48 hours) (Marancik 1976). Haines (1981) found no mortality of brook trout, and a bioassay of young-of-the-year indicated no mortality within an area treated with carbaryl. The mean fish brain acetylcholinesterase activity was 15-34 percent lower for fish within the treated area, however, depression disappeared 24 to 48 hours later.

In response to double carbaryl applications (0.31 and 0.69 lbs carbaryl/acre) brook trout exhibited a slow, delayed drop in acetylcholinesterase activity after the first treatment (Gibbs et al. 1979). These depressions were short-lived, since 30-day samples revealed no significant differences between treated and untreated samples.

Exposure to split applications of carbaryl decreased oxygen consumption by brook trout (Gibbs et al. 1979). However, Brown (1980) concluded split applications of carbaryl had no apparent effect on oxygen consumption by brook trout.

White suckers responded to carbaryl exposure with increased brain acetylcholinesterase activity levels (Marancik 1976; Hulbert 1978). Marancik (1976) reported that tissue analyses of Atlantic salmon, eastern brook trout, and the slimy sculpin yielded no carbaryl residue in any of the fish species 24, 48, and 168 hours after exposure to an application of 1.0 lb/acre of carbaryl.

Large numbers of dead juvenile and a few dead adult nine-spined sticklebacks were observed in one area during operational spraying in Main of 0.75 lb carbaryl/acre, in 1978 (Courtemanch and Gibbs 1979). Whether carbaryl caused the mortality in 1978 is uncertain, since such mortality has not been found before or since. The following year caged adult sticklebacks were unaffected by split (two) applications of 0.31 and 0.69 lb carbaryl/acre (Gibbs et al. 1979).

Brook trout in Main responded to increased insect drift by increasing the numbers and volume of prey taken per fish (LOTEL 1977, Hulbert 1978, Gibbs et al. 1979). Increased feeding activity persisted 2 to 4 days then returned to prespray levels. In multiple applications, (two applications totaling 1.0 lb carbaryl/acre) fish feeding increased after the first application but not after the second (Gibbs et al. 1979). Increased feeding may not enhance fish productivity since there are indications that subsequent feeding declines later in the season (Gibbs et al. 1979).

A study of buffered streams by McCullough and Stanley (1980) during the 1979 Main spruce budworm project indicated that feeding and acetylcholinesterase activity of young-of-the-year brook trout were not adversely affected. Ott and Wilder (1980) studied the effects of an application of 0.75 lb carbaryl per acre on young brook trout in one unbuffered and one buffered stream in Maine. No physiological changes in brook trout were detected that could be attributed to carbaryl contamination. In addition, these workers concluded that it is extremely unlikely that streams accidentally contaminated by carbaryl during spraying for spruce budworm control in Maine would have fish mortality.

A quantitative change in river brook trout diet from fish and oligochaetes (segmented worms), to stoneflies, mayflies, and larval flies persisted approximately 4 days after a 0.75 lb carbaryl/acre application (Hulbert 1978). This change in fish diet is expected because rock-clinging stoneflies and mayflies exposed to insecticides become free floating and are thus more available as fish food. Increased feeding on stoneflies after carbaryl application was also reported in stream brook trout. Terrestrial prey became more abundant food items for brook trout 2 weeks after application in Maine (LOTEL 1977).

Invertebrates

A temporary decline can be expected in some aquatic insect populations if water is inadvertently treated. Population resurgence should, over time, replenish the supplies of these fish-food organisms. The number of aquatic insects, such as stoneflies and dragonflies, may be reduced in those bodies of water that are contaminated with carbaryl (Burdick et al. 1960; USDA 1964; Coutant 1964; Pillow 1973). No adverse effect was seen where streams were avoided (Felley 1970). The population depression will vary with the degree of contamination. Inasmuch as contamination of these nontarget areas should be minimal (USDA 1964), and because the spraying involves a single-application, the aquatic organisms should suffer no more than a temporary depression.

A study by Barker (1964) showed that when carbaryl was applied aerially at 1.0 pound per acre, juvenile mayfly and stonefly populations were substantially reduced in and immediately below the sprayed area. No apparent toxicity to caddisflies or other orders of insects was suggested. Burdick et al. (1960) also noted that carbaryl (in oil suspension) was found highly toxic to mayflies and stoneflies. Unlike Barker (1964), Burdick et al. (1960) found that carbaryl was also highly toxic to caddisflies. Other groups of aquatic insects were apparently less affected over short exposure periods. A progressive effect on insect populations from upstream to the lower sections of a spray block downstream was believed to be correlated with increased exposure time. Willcox (1972) found no apparent toxicity of carbaryl (Sevin 4 Oil) to damselflies and dragonflies in a study in New Jersey.

In 1973, Pillow revisited Pennsylvania test streams that had been deliberately treated in 1972 with carbaryl applied as Sevin 4 Oil. This treatment had practically eliminated aquatic insects from the sprayed parts of the streams shortly after the insecticide was applied (Pillow 1973). The 1973 sampling showed normal populations of aquatic insects in both test streams.

Aquatic insects were monitoried in three streams treated with 1 pound of carbaryl (Sevin 4 Oil) per acre in New Mexico. The streams were to be protected from spraying by a 100 foot buffer on each side. Accidental overspray of one of the creeks resulted in a substantial reduction of aquatic insects. The following year insect biomass had recovered, although a few taxa of Plecoptera, Trichoptera, and Diptera had not become fully re-established (Parker et al. 1980).

The severity of the reduction of certain aquatic insects, recognized as important fish-food organisms, upon the fish production and fish-holding capacity of sprayed streams depends upon many factors. On the basis of his field work, Barker (1964) concluded "Because of the general adaptability of most fish species, this reduction in fish-food organisms is not expected to seriously affect the production of fish-holding capacity of the stream either in or below the treated area."

Aquatic Plants

The higher plants are not expected to sustain any detrimental effects from the proposed carbaryl application. Phytoplankton, however, might be affected by carbaryl if concentrations reach 0.2 ppm (USDI 1960).

In another study, carbaryl at 1 ppm did not seriously affect growth of three resistant species of phytoplankton, but two others were completely suppressed (Ukeles 1962). Concentrations of 10 ppm were lethal to three species.

Effects of carbaryl on fresh water species of algae may be reflected in results of a test with Scenedesmus quadricaudata. Carbaryl did not harm the organism, but instead stimulated its growth, possibly through increased availability of nitrogen produced by the metabolism of carbaryl in water. This might cause a bloom of algae in fresh water receiving large amounts of carbaryl (Stadnyk and Campbell 1971).

EFFECTS ON THE PHYSICAL ENVIRONMENT

Water Supplies

Several studies have been conducted to determine carbaryl residues in streams and ponds. In a 2-year study (Fahey et al. 1968) where carbaryl was applied to a field to control the alfalfa weevil, pond water samples displayed a carbaryl residue at twice the minimum detectable residue of 0.001 ppm (=1.0 ppb). Concentrations of carbaryl in two creeks within a gypsy moth treated area in New Jersey averaged 30 ppb on the day of treatment, 1.5 ppb the following day, and 1 ppb 5 days later (USDA 1964). In a similar study on Cape Cod, samples collected at intervals after spraying showed small amounts of carbaryl ranging from .001 to .003 ppm (Boschetti 1966). In 1971, samples of water and pond mud were collected after carbaryl application against gypsy moth in New York (Devine 1971). Application of Sevin Sprayable and Sevin 4 Oil were made at the rates of 1 pound active ingredient per acre. Carbaryl residues in ponds and streams ranged from nondetectable levels to 0.05 ppm during an 8-day period following spraying. Residues in pond mud ranged from nondetectable to 0.62 ppm.

In another study, two ponds (about 30 acres each in size) were exposed to an aerial spray application of undiluted Sevin 4 Oil at the rate of 1 pound active ingredient per acre (Romine 1971). Water samples were taken from the ponds and analyzed for carbaryl residues. The initial residue of about 0.5 ppm had almost disappeared in 4 days. The maximum residue at 4 days was 0.05 ppm and water samples taken at 8 days after spraying revealed residues of 0.01 and 0.02 ppm. Application of Sevin 4 Oil applied at 1 pound carbaryl per acre resulted in a rapid and complete dissipation of residues from the study watershed within a maximum of 10 days, and generally within 48 hours (Willcox 1972).

Felley (1970) hypothesized that carbaryl is not detected in very large amounts in streams within treated areas because it may form plant stable conjugates be volatized, be metabolized by plants and microorganisms, altered by sunlight, or enter the streams as nontoxic water soluble compounds.

The attitudes of the USA and the USSR toward carbaryl residues in water are reflected in their water quality standards. A study in Russia for hygienically acceptable levels of carbaryl in bodies of water recommended concentrations not to exceed 0.1 mg/liter (Gabrilevskaya et al. 1965). In the United States, public health standards have not been set for carbaryl in water. Instead, the limits for the combination of carbamates and organic phosphates have been set at 0.1 mg/liter of water (U.S. Department of HEW 1969). These limits apply to drinking water, as well as to treated water and untreated raw ground water used for domestic and food processing purposes. Careful applications of carbaryl should preclude concentrations of 0.1 mg/liter or greater.

Soil

Carbaryl residues are expected to concentrate in the upper soil surface because of interception and biodegradation by the organic litter layer and adsorption by the soil particles.

Insecticide residues are concentrated in the upper 3 inches of soil (Lichtenstein et al. 1962). The results of the analysis of soil samples collected before a gypsy moth spray program on Cape Cod showed that carbaryl was initially present in the soil in concentrations ranging from 0.008 to 0.022 ppm. Such measurements may represent method sensitivity rather than a measure of carbaryl present. Samples collected at unspecified intervals after spraying showed concentrations of carbaryl ranging from 0.018 to 0.300 ppm (Boschetti 1966). Soil samples taken over a 16-day period following the application of 1 pound of carbaryl per acre resulted in residues that ranged from nondetectable to 3.2 ppm (Devine 1971). In another study, soil samples were taken in conjunction with an alfalfa weevil control program employing carbaryl as a 50 percent wettable powder suspension at 3 pounds per acre (Fahey et al. 1968). Residues ranged from 0.006 ppm before application and 0.114 ppm 1 day after spraying to a nondetectable amount 5 months after treatment. No adverse effects are known from these studies.

APPENDIX B

RISK ASSESSMENT FOR USE OF CARBARYL IN REGION 1 MOUNTAIN PINE BEETLE SUPPRESSION PROJECTS

RISK ASSESSMENT FOR USE OF CARBARYL IN
REGION 1 MOUNTAIN PINE BEETLE SUPPRESSION PROJECTS

1. INTRODUCTION

1.1 Purpose and Scope

This risk assessment evaluates the human health risks associated with using the insecticide carbaryl. This analysis is designed for both decisionmakers and interested members of the public, and includes discussions of normal treatment operations and risks arising from accidents or abnormal situations. To assist the reader, an effort is made to present the scientific evidence as clearly as possible in a nontechnical format. Scientific terminology and mathematical formulas are necessary to provide the documentation for the analysis. Most calculations have been excluded in this discussion, but they are presented in Attachment A. A glossary of terms has been included in the Draft Environmental Impact Statement (DEIS). Terms used in the text and defined in the glossary are marked with an asterisk.

The analysis consists of three general process steps:

1. Hazard Identification through a review of toxicology data.

2. Exposure and Dose Analysis showing the amount, frequency, and number of possible human exposures and consequent doses.

3. Assessment of Risk by comparing the human dose data from step 2 with toxicology information from step 1.

In the hazard identification, toxicology information is reviewed for both acute (short-term health effects due to a relatively large dose) and chronic effects (over a longer time period due to a series of small doses). The No Observable Effect Levels (NOEL), Acceptable Daily Intake (ADI), and when possible, the Lowest Observable Adverse Effect Level (LOAEL) were obtained from literature or from the U.S. Environmental Protection Agency (EPA). (Refer to the glossary for definitions). These values are used to establish threshold doses at which health effects such as teratogenicity (birth defects), fetotoxicity (effect on the fetus), and neurotoxicity (effect on the nervous system) are indicated by the toxicity studies. The dose needed to kill 50 percent of the test animals (LD_{50}) was used to give an indication of acute dose response. The cancer and mutation risks are assessed on the assumption that every dose of a carcinogen increases one's probability of developing cancer. A cancer risk assessment is conducted on N-nitrosocarbaryl, a proven animal carcinogen that could possibly form as a result of carbaryl doses. The risks of heritable mutations are discussed based on available test data on bacteria, yeast, plants, mammalian cells in culture, and whole animal studies.

The exposure and dose analysis assumes a representative project vicinity and time frame. Possible doses are calculated for workers applying pesticide and the general public in the vicinity of spray sites.

Exposures under the different scenarios were designed to be additive in order to calculate risks due to cumulative exposures for a single project. For example, a worker could conceivably be exposed on the job and then consume contaminated food or water. The dose levels to maximum-exposed members of the affected population are compared to NOEL and ADI values for carbaryl. This comparison indicates the possibility of adverse human health impacts from maximum calculated doses, The cancer risk to affected populations is also provided based on the assumption that each dose increased the probability of developing cancer. Finally, to provide the reader a perspective for the risks associated with insecticide use, the risks of insecticide use are compared to other incidents or events which occur in our society.

1.2. Data Sources and Information Gaps

Council on Environmental Quality regulations (40 CFR 1502.22) require that an environmental impact statement always identify any gaps in relevant information or scientific uncertainty when evaluating significant adverse effects. If the information relevant to adverse impacts is essential to a reasoned choice among alternatives and is not known, and the overall costs of obtaining it are not exhorbitant, the agency shall gather the information and include it in the Environmental Impact Statement. However, if the overall costs of obtaining the information are exhorbitant or the means to obtain it are not known (the means for obtaining it are beyond the state-of-the-art), the agency shall weigh the need for the action to proceed in the face of uncertainty. If the agency proceeds, it shall include a worst-case analysis and an indication of the probability or improbability of its occurrence.

Carbaryl is currently registered under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) by the Environmental Protection Agency (EPA) for the control of mountain pine beetle. Under this authority, EPA has recently issued a reregistration standard for carbaryl (U.S. EPA 1984). The EPA Registration Standards Program complies with a Congressional mandate that EPA reregister all pesticides. The program involves a review of the scientific data base supporting pesticide registration. This review identifies essential missing data which may not have been required when the pesticide was initially registered. It also identifies studies that are considered insufficient by the current protocol standards. The Registration Standards Program also provides the authority for EPA to require registrants to submit the missing or replacement data (data call-in) under the authority of Section 3(c)(1)B of FIFRA. Registrants of carbaryl have been requested to repeat the teratology (birth defect) study in beagle dogs. Metabolism studies in the beagle dog versus the rat have also been required to determine if dogs metabolize carbaryl differently than other mammals. They were also required to conduct a 1-year feeding study in dogs to determine the effects of carbaryl on kidney function and additional studies on environmental fate and impact to nontarget organisms. All labels for end-use products must bear an Environmental Hazards paragraph designed to protect wildlife (U.S. EPA 1984).

This document reviews information available in EPA's registration standard and information from the scientific literature. The availability of information necessary for this analysis is indicated below:

HEALTH EFFECTS INFORMATION	AVAILABILITY
Acute Toxicity*	Available
Systemic Toxicity*	Available
Epidemiology*	Partial[1]
Teratogenicity*	Available
Mutagenicity*	Available
Carcinogenicity*	Available
Human Exposure	Available
Nontarget Organisms	Available
ENVIRONMENTAL FATE	
Animals	Partial[2]
Vegetables	Available
Water	Available

[1]One study dealing with birth defects.
[2]Data found for agricultural situations, but site-specific data for mountain pine beetle control is lacking.

Since the epidemiology or human toxicology data was generally lacking, adverse effects were evaluated using risk analysis techniques based on test animal data.

Studies were lacking on cumulative and synergistic effects of carbaryl in combination with other chemicals that might be in the environment. There is also uncertainty about the risk of heritable human mutations, the assessment of which is beyond the state-of-the-art. Lastly, uncertainties were identified in existing data about whether carbaryl could form N-nitrosocarbaryl in humans and how to extrapolate animal data to humans.

The costs of filling these data gaps for a compound and estimated times to conduct the tests are listed below (these are taken from Gypsy Moth Suppresssion and Eradication Projects FEIS as Supplemented - 1985, USDA-FS/APHIS):

	COSTS/TEST ($)	TIME/TEST (YR)
Epidemiology Tests	$300-500,000	
Exposure (Human)	100-200,000	2 years
- Pharmacokinetics* (Rat)	140,000	1 year
- Pharmacokinetics (Mouse)	140,000	2 year
RESIDUE ANALYSIS		
Animals	60-100,000	1-2 years
Vegetation	60-100,000	1-2 years
Oncogenicity* (Rat)	440,000	3 years
Oncogenicity (Mouse)	500,000	3 years

Cost of studies to determine cumulative or synergistic effects would be multiples of these costs. For synergistic effects, the costs would escalate rapidly as additional chemicals are added to the study. An infinite time period was designated for the epidemiology studies because of the long time period over which epidemiologists look for effects in cohort studies and the large number of case-control studies that could be run for specific health responses (including all types of cancer, birth defects, and abortions). Because of the costs and time involved, a worst-case analysis was done to assist the decisionmakers in weighing the risk of proceeding with suppression projects in the face of uncertainty.

Where uncertainties or data gaps are identified, these data gaps are generally filled by extrapolation from the existing data. Assumptions are used to model exposure levels when the existing data base is considered insufficient. When assumptions were needed, a range of assumptions from realistic to extreme (worst-case) were used. To be cautious in the area of uncertain data, extrapolations and assumptions are designed to overestimate risk to humans. In completing the assessment, no data gap or scientific uncertainty encountered was considered so significant that the risk analysis could not be completed.

This risk assessment builds upon and uses methodology similar to the carbaryl portion of Appendix F, Gypsy Moth Suppression and Eradication Projects, Final Environmental Impact Statement (FEIS), as Supplemented 1985 (USDA Forest Service/Animal Plant Health Inspection Service). However, two major changes have been made in this assessment:

1. Additional bioassay data from Lijinsky and Taylor (1976) and Lijinsky and Schmahl (1978) cancer studies has been used to define the cancer potency of N-nitrosocarbaryl*. The cancer potency values of the two tests are averaged to define potency in this analysis. This increases the cancer potency by about 60 times over that used in the Gypsy Moth Assessment.

2. The worst-case dosage (exposure) is defined by adding two standard deviations to average dose values. This is equivalent to setting the upper worst-case value at the 95 percent confidence limit (statistical significance). This means that at least 97.5 percent of the values would be below these upper limit values. In the Gypsy Moth Assessment, the "realistic" doses were simply doubled to establish the high range of exposure.

2. ANALYSIS OF THE HAZARDOUS CHARACTERISTICS OF CARBARYL

2.1. Potential Health Effects

During the past several years, carbaryl has received considerable notoriety as a suspected or "proven" carcinogen, teratogen, and mutagen. The stimulus for many of these allegations has been use of carbaryl to control gypsy moth or spruce budworm throughout the United States which has often resulted in the aerial spraying of populated areas. In order to evaluate human health risk associated with the use of carbaryl to protect selected sites within Region 1 from mountain pine beetle, a risk analysis was conducted.

The organocarbamate carbaryl (1-Naphthyl N-methylcarbamate), more commonly known by the trademarks Sevin and Sevimol, is considered a slightly toxic insecticide (oral LD_{50} in rats of 510 mg/kg). This insecticide has seen widespread use during the past 20 years.

Carbaryl acts principally as a nervous system poison by inhibiting the action of acetylcholinesterase, an enzyme essential to proper nerve function. When human poisoning has been induced by inhalation or skin contact, the following symptoms have been reported (Morgan 1982): nausea and dizziness, headache, excessive perspiration, vomiting, abdominal cramping, dimness of vision, skin rash, weakness, and difficulty in breathing. In those cases in which poisoning occurred orally, signs and symptoms such as miosis (pinpoint pupils), excessive salivation, incoordination of muscles, epigastric pain, sweating, disturbed vision, and pulmonary edema (swelling of lung tissue) occur, as well as nausea, vomiting, hyperreflexia (excessive nerve sensitivity), pallor, intestinal colic, nasal discharge, headache, lacrimation (eyes watering), tremors, difficulty in sleeping, and abdominal cramps. The severity of these symptoms depends upon the amount and duration of human exposure. Complete recovery from acute poisoning is swift, often within 20 hours, especially if an antidote, atropine, is administered.

Because lethality or acute illness represent rather extreme benchmarks for judging the safety of herbicides, policies regarding acceptable intake levels for chemical compounds are most often based on toxicity tests designed to find the highest dose level that produces no effects in the animal species tested over long periods of time. This dose is the no observed effect level (NOEL). The NOEL is the dose level below the lowest dose level to affect the organism's health or well being over the test duration. A NOEL can be determined for single or short-term acute doses, subchronic (generally 30- to 90-day dosing studies) tests, and chronic tests of a compound. All other things being equal, the longer the dosing duration upon which a NOEL is based for a particular animal species, the more significant the resulting value.

The main purpose of toxicity tests in animals is to provide data that can be used to assess the human risk or evaluate the human hazard associated with the use of a particular substance. The characteristics of exposure and toxicological effects come together in a relationship customarily referred to as the dose-response relationship (see, for example, Doull et al. 1980). This relationship can be depicted graphically by plotting increasing dose and corresponding response. Response can be measured in several ways including the intensity of response (e.g., increase in enzyme inhibition) or in terms of the numbers of animals exhibiting response (e.g., cumulative numbers of dead animals with increasing dose).

Dose-response curves typically exhibit similar patterns. Above a certain dose level the response increases with dose until a saturation effect is observed (e.g., all the animals are dead). For many responses a "threshold" can be defined which is the dividing line between the no-effect and effect levels of dose.

After establishing the toxic characteristics of a chemical in animal tests, the implications of these studies for human exposure and doses must be determined.

The time-honored approach for establishing safe levels of pesticides to which humans may be exposed is to divide the threshold dose or NOEL established from chronic animal studies by a "safety factor" (Doull et al. 1980 and NAS-NRC 1977). The safety factors are needed to account for differences in route and duration of exposure, absorption, metabolism, and excretion between humans and test animals. For example, on a body-weight basis, man is generally more vulnerable to drugs than experimental animals by a factor of 6-12 (NAS-NRC 1977).

ADIs are established by EPA or the World Health Organization by dividing a NOEL, usually from a long-term feeding study, by a safety factor that takes into consideration both intraspecies and interspecies differences. This means that sensitive individuals in a population (old, young, weak, debilitated), as well as the uncertainty of data extrapolation from animals to humans, are considered in setting a "safety factor."

2.2. Toxicology Review

The following is a brief review of the literature published to date on the subject of general toxicology and teratogenicity of carbaryl. Studies that provide oral toxicity data generally report doses in one of two ways--either as the concentration in food (parts of pesticide per million parts of food, ppm) or as the concentration in the body of the test organism (milligrams of herbicide per kilogram of body weight, mg/kg). Doses reported as ppm in food in the original study are also converted to mg/kg (body weight) in the review below, using food to weight ratios from USDA (1984, p. 35).

2.2.1. General Effects

In an extensive 2-year study, Carpenter et al. (1961) fed rats carbaryl mixed with feed. At the completion of the study, the authors concluded that none of the tissues from rats receiving the highest dosages (400 ppm in the diet or 20 mg/kg body weight) showed permanent degenerative changes which could be attributed to the toxicity of carbaryl. The authors also reported mild, transitory renal changes characterized by cloudy swellings of kidneys. EPA (1984) reported a NOEL of 200 ppm (10 mg/kg) for effects on kidneys and liver after reviewing the same study.

Carpenter et al. (1961), in a 1-year feeding study with dogs, observed similar renal characteristics in both the treated and control groups (with a somewhat higher but not significant incidence in the former). They concluded that these changes were thought to be transient rather than degenerate and that, after examining all tissues, dogs receiving the highest dosage (7.2 mg/kg) showed no permanent degenerative changes.

EPA (1984) also reported a cholinesterase NOEL of 10 mg/kg in rats from a 7-day feeding study; it took 50 mg/kg to cause symptoms of poisoning (53 percent decrease in cholinesterase activity). Dogs had a 33 percent inhibition of cholinesterase activity when dosed with 375 mg/kg (Carpenter et al. 1961). Smalley et al. (1969) also reported that the clinical signs of carbaryl poisoning of pigs at 150 mg/kg/day resembled those of other cholinesterase inhibitors.

One human oral-feeding study with carbaryl is reported in the literature (Wills et al 1968). In this study human volunteers were fed carbaryl for 6 weeks at 0.06 mg/kg, or 0.13 mg/kg, or were fed placebo capsules (control group). No effects were noted in the subjects fed 0.06 mg/kg in any measurements, including cholinesterase inhibition, brain activity, and blood and clinical chemistry. At the 0.13 mg/kg feed level, the only effect noted was a decrease in the ability of proximal tubules of the kidney to reabsorb amino acids. This effect ceased after dosing ended.

In reviewing this study EPA has noted the following:

> The NOEL in the human study (Wills et al 1968) was not utilized in the derivation of the ADI (acceptable daily intake of carbaryl) because results of this study were not supported with individual data, were limited to only a few individuals per dose (all male), was conducted for only a short period of time, and provided opposite results at the low versus high dose compared to control values. Furthermore, the ratio of amino acid to creatinine nitrogen is only a rough measure of the reabsorptive capacity of the proximal tubules. None of the subjects, at any dose, experienced any other effects attributable to carbaryl. Clinical chemistry and urinalysis examinations in the rat and dog were incomplete, so that no subsequent comparison could be made. A 1-year dog-feeding study is being required in order to determine the effects of carbaryl on kidney dysfunction. Because of the inconclusiveness of the currently available data, no regulatory action based on a positive reversible kidney effect is warranted at this time (U.S. EPA 1984).

This analysis will discuss the possible renal effects where warranted by the human exposure and dose assessment.

2.2.2. Viral Enhancement

The question of viral enhancement* as a possible adverse effect of human exposure was first studied by two University of Maine researchers (Abrahamsen and Jerkofsky 1981, as reported in U.S. EPA 1980). They found that carbaryl increased the production of human herpes virus cells (Varicella-Zoister) in human cell cultures. A followup study, commissioned on the Canadian Forest Service because of the possible association between viral enhancement and Reye's syndrome, found no viral enhancement caused by carbaryl (Brookman et al. 1984). However, the later study used cultured mouse cells instead of human cells. Because the possibility of viral enhancement has only been demonstrated in tissue culture, these results cannot be extrapolated to humans. At this time, it is best to conclude that carbaryl may pose some undemonstrated, yet uncertain, risk of viral enhancement: The U.S. EPA (1984) concluded "that available data do not constitute a basis on which to conclude that carbaryl poses a human hazard in terms of viral enhancement."

2.2.3. Teratogenic, Fetotoxic, and Reproductive Effects

The use of pesticides can cause concern over the possible prenatal effects from the exposure of pregnant women to such pesticides. Teratogenesis refers to irreversible malformations caused early in the development of the fetus when organs are just forming. Teratogenesis should be distinguished from the term fetotoxicity. Fetotoxicity refers to reversible effects on the fetus, such as lowered birth weight, delays in ossification, etc. These effects can be overcome upon removal of the toxicant. Fetotoxic effects are often noted at lower doses than teratogenic effects and NOEL's can be determined for both fetotoxic and teratogenic effects of pesticides.

A number of studies have been conducted on the teratogenic or reproductive potential of carbaryl in various species of mammals. The findings vary with the species tested and the test protocol. In the mouse, Murray et al. (1979) showed that carbaryl given from day 6 through day 15 of gestation by gavage (at 100 or 150 mg/kg/day) or in diet (1,166 mg/kg/day) did not result in increased numbers of birth defects.

Some reduced fetal weight and delays in skeletal ossification (reduced rate of bone hardening) were noted in the dietary experiment at 1,166 mg/kg/day.

In the same series of reproduction studies, (Murray et al. 1979), rabbits were given carbaryl at rates of zero, 150, or 200 mg/kg/day by gavage from day 6 through 18 of gestation. Carbaryl had no statistically significant effect on the number of offspring per litter, frequency of resorptions*, or pregnancy rate at either dose. However, there was a significant increase in omphalocele (fissures in the ventral body walls) of the offspring at the 200 mg/kg/day dose that was related to maternal toxicity (weight loss and diarrhea). In contrast to these results, Robens (1969) reported no evidence of embryotoxcity or maternal toxicity of rabbits of the same breed given carbaryl at doses up to 200 mg/kg/day during the same gestation period. The difference in results probably reflect the differences of dosing method; gavage* versus gelatin capsule.

Collins et al. (1971) concluded that rats fed carbaryl in their diets at 10,000 ppm (500 mg/kg) demonstrated decreased fertility. They also described a dose-related suppression of mean litter size, mean body weight, and survival of 1- to 4-day-old rats. A no-effect level of below 2,000 ppm (100 mg/kg) was reported. Weil et al. (1972 and 1973) conducted similar multigeneration studies in rats and guinea pigs. Animals were dosed with carbaryl by both dietary (0, 7, 25, 100, and 200 mg/kg/day for rats and 0, 100, 200, and 300 mg/kg/day for guinea pigs) and peroral intubation* (0, 3, 7, 25, and 100 mg/kg/day for rats and 0, 50, 100, and 200 mg/kg/day for guinea pigs). In addition to cholinesterase inhibition, the authors found increases in parental mortality, incidence of fetal resorption*, and length of gestation; and decreases in the number of live-born rats, percentage of females that produced litters, number of fetuses, number of live fetuses, and parental body weight, for the 100 mg/kg/day intubation dose. No effects were reported at lower intubation doses. With the exception of reduced maternal weight gain, no adverse effects were observed at any of the dietary doses. The authors reported no significant skeletal or soft tissue abnormalities in the fetuses of the guinea pigs. There was an indication of reduced maternal weight gain at the 200 mg/kg/day intubation dose, but difference between treated and untreated control pigs was not statistically significant.

The results from the Weil studies contrast with those reported by Roben (1969). Roben (1969) reported skeletal defects in guinea pigs at intubation doses of 300 mg/kg/day. Weil et al. (1973) concluded that Roben's (1969) high dose was maternally toxic because 38 percent of the mothers died. They also concluded that only teratogenicity experiments that use dietary dosing should be used to extrapolate to humans.

Of greatest concern are teratogenicity studies showing birth defects in beagle dogs fed doses ranging from 3.625 to 50 mg/kg/day (Smalley et al. 1968 and Imming et al. 1969 as reported in U.S. EPA 1980). Smalley et al. (1968) reported low irregular incidences of birth defects at all but the lowest dose. The authors also reported maternal toxicity (difficult births) at all dose levels. Imming et al. (as reported in U.S. EPA 1980) found similar birth defects at doses greater than 5.0 mg/kg/day.

There has been an epidemiological study to assess carbaryl-related birth defects in humans. Halpin (as reported in U.S. EPA 1980) investigated the possibility of increased birth defects (teratogenicity) in New Jersey municipalities where carbaryl was aerially applied for gypsy moth suppression and whether or not a relationship in time between the occurrence of birth defects and this spraying existed. Although this was not an exhaustive study of birth defects in the area examined, it did provide a basis for concluding that there was no association between the spraying of carbaryl (Sevin 4 Oil) for gypsy moth and the birth defects reported from Cap May County.

The EPA reviewed these and other data regarding the potential ability of carbaryl to cuase birth defects and other reproductive effects (U.S. EPA 1980). They concluded that carbaryl could cause adverse effects to the embryo or fetus, but only if administered at sufficiently high dose levels and sufficient lengths of time to cause toxic effects in the mothers. As with general toxic effects, the risks of birth defects or reproductive effects in the human population is very much dependent upon the amount of possible exposure to carbaryl. Table 1 lists NOELs for teratogenicity and other toxic effects that can be compared to human exposure levels to determine possible risks.

Table 1.--Summary of established No Observable Effect Levels (NOEL) and Lowest Observed Adverse Effect Levels (LOAEL) for carbaryl for various mammals.

Animal	Test Type of test	Results	Reference
General Toxicity			
Rat	2-year feeding	Systemic NOEL = 200 ppm (10 mg/kg) LOAEL = 400 ppm (20 mg/kg) (swelling of kidneys and liver)	Carpenter et al. 1961
	7-day feeding	Cholinesterase NOEL - 10 mg/kg/day LOAEL = 50 mg/kg/day (53 percent decrease in CHE)	U.S. EPA 1984
Dog	1-year feeding	Cholinesterase ≥ 7.2 mg/kg/day	Carpenter et al. 1961
		Systemic NOEL = 1.8 mg/kg/day LOAEL = 7.3 mg/kg/day (swelling in kidney)	Carpenter et al. 1961
Human	Subacute 6 weeks	NOEL = 0.06 mg/kg/day LOAEL = 0.12 mg/kg/day (reversible decrease in reabsorption of amino acids by proximal tubules)	U.S. EPA 1984
Pig	Neurotoxicity	LOAEL ≤150 mg/kg/day	Smalley et al. 1969
Teratogenic/reproductive			
Mouse	Teratogenic (diet)	Teratogenic NOEL ≥1,166 mg/kg/day Maternal LOAEL = 1,166 mg/kg/day (decreased weight gain) Fetotoxic LOAEL = 1,166 mg/kg/day (reduced embryo weight)	Murray et al. 1979
	(gavage)	Teratogenic NOEL ≥150 mg/kg/day Matnrial LOAEL = 150 mg/kg/day (decreased weight gain, cholinesterase inhibition)	Murray et al. 1979
Rabbit	Teratogenic (gavage)	Teratogenic NOEL = 150 mg/kg/day Teratogenic LOAEL = 200 mg/kg/day (omphalocele)* Maternal NOEL = 150 mg/kg/day (weight loss)	Murray et al. 1979
	(diet/capsule)	Teratogenic NOEL ≥200 mg/kg/day	Roben 1969
Rat	Teratogenic (diet)	Teratogenic NOEL ≥500 mg/kg/day Maternal LOAEL = 500 mg/kg/day (decreased weight gain) Fetotoxic LOAEL = 500 mg/kg/day	Weil et al. 1972

	Reproductive (3 generations) (diet)	Reproductive NOEL ≥10 mg/kg/day Maternal LOAEL ≥10 mg/kg/day Fetotoxicity LOAEL = 10 mg/kg/day (dilated uterine gland in third generation rats)	Weil et al. 1972
	Teratogenic (diet)	Reproductive NOEL = 200 mg/kg/day	Weil et al. 1973
	Gavage	Reproductive NOEL = 25 mg/kg/day Maternal LOAEL = 100 mg/kg/day (decreased weight gain, cholinesterase inhibition) Reproductive LOAEL = 100 mg/kg/day (decreased number of fetuses)	Weil et al. 1973
Guinea pig	Teratogenic (diet)	Teratogenic NOEL ≥300 (HDT)[1] Maternal NOEL ≥300 mg/kg/day Fetotoxic NOEL ≥300 mg/kg/day	Weil et al. 1973
	Teratogenic (gavage)	Teratogenic NOEL ≥200 (HDT)[1] Maternal LOAEL 200 mg/kg/day (decreased weight gain) Fetotoxic NOEL ≥200 mg/kg/day (HDT)	Weil et al. 1973
Dog	Teratogenic	Teratogenic NOEL = 3.725 mg/kg/day	Smalley et al. 1968 (as cited in USEPA 1980)
	(diet)	Teratogenic LOAEL = 6.25 mg/kg/day (lack of tail, abdominal fissures, failure of skeletal formation and extra toes)	
Mutagenicity			
Mouse	Dominant lethal	NOEL = 50 mg/kg/day LOAEL = 1,000 mg/kg/day	Epstein et al. 1972

[1] HDT means highest dose tested.

2.2.4 Nonthreshold Responses

To evaluate the ability of the insecticides to produce genotoxic effects such as tumor initiation or heritable mutations, NOEL or threshold doses are not used. Thresholds are not assumed because it is conceivable that only one or a few molecules of an active chemical may be sufficient to cause certain types of changes in DNA which could result in either formation of neoplastically transformed cells (cancer) or heritable mutagenic effects (birth defects).

In the case of cancer, individual and population risks can be quantified using various models if there is scientific evidence to suggest a chemical is a carcinogen. Since quantitative risk models are not available for mutagencicity, a multi-step process of evaluating a pesticide's ability to cause mutations and to interact with germinal tissue (gonads) is used to assess the qualitative potential of mutagenic risk in humans (see, for example, U.S. EPA 1984 or U.S. EPA 1980). The first step involves an analysis of the evidence of a pesticide's ability to cause mutations in bacteria, microorganisms, insects, plants, mammalian cells in culture, and germinal cells in whole animals; while the second step involves an analysis of its ability to produce these events in mammalian gonads. Greater weight is placed on tests that show changes in germinal tissues than in somatic cells, on tests performed in vivo (within the body) rather than in vitro (outside the body), and in mammalian species rather than in submammalian species.

2.2.5. Mutagenicity

EPA reviewed existing data on mutagenicity of carbaryl during the Rebuttable Presumption Against Registration (RPAR) process (U.S. EPA 1980) and found that carbaryl was reported to produce gene mutations in bacteria, fruit flies (Drosophila), and mammalian cells in culture. Cytogenic* tests indicate that carbaryl may induce chromosomal effects in mammalian cells in culture, whole animals, and plants, and cause primary DNA damage in cultured human cells (U.S. EPA 1980 and U.S EPA 1984). Collectively, these factors suggest that carbaryl may act as a mutagen. To cause heritable effects in man; however, it must reach the germinal tissue (gonads). There is some suggestive, but not conclusive, evidence that carbaryl may reach mammalian gonads. For example, Shtenberg and Rybakova (1968) determined that the tests of carbaryl-treated rats showed edema* of interstitial* tissue, destruction of germinal epithelium*, and a reduction of spermatocytes*. In female rats, the estrous cycle was prolonged. While a direct effect of carbaryl was not ruled out by the authors, the site of action was thought to be the anterior pituitary which caused a secondary change in the reproductive glands. There have also been two epidemiological studies dealing with sperm counts of workers formulating carbaryl (Wyrobeck et al. 1980 as reported in U.S. EPA 1980) which showed that carbaryl-exposed workers had depressed sperm counts. However, the epidemiological studies are flawed because the differential age of the workers (the exposed workers were also older which could account for more sperm abnormalities). In addition, there were no differences between low or high exposure. The study also showed that workers who were no longer exposed to carbaryl did not have greater incidence of sperm abnormalities. This type of information adds to the high uncertainty about the mutagenic risk of carbaryl to humans. EPA concluded that the weight of evidence is that carbaryl poses low mutagenic risk due to the weak mutagenic response noted in the mutagenicity studies and due to the suggestive rather than conclusive evidence about whether carbaryl reaches germinal tissue.

2.2.6 Carcinogenicity

In the 2-year feeding study of rats conducted by Carpenter et al. (1961), the authors concluded that no single type of tumor or site of origin was associated with the inclusion of carbaryl in the diet (up to 400 ppm), nor was the incidence of tumors in the carbaryl-fed group different from that of control rats. Further, in a lung cancer study in two strains of tumor-susceptible mice (400 mg/kg/week), the authors reported that carbaryl did not increase the incidence of tumors, lung infections, or death over the control group.

In a National Cancer Institute Study, Innes et al. (1969), fed mice carbaryl (4.64 mg/kg/day) for 18 months and concluded that carbaryl gave no evidence of tumor formation. They further stated that, while there was no way to predict whether or not humans were more susceptible than mice to the induction of tumors, the dose received by the mice was far in excess of that likely to be consumed by humans.

The EPA (1980) evaluated these and seven other studies during the RPAR review of carbaryl. They concluded that, although all of the available tests had design or reporting deficiencies, the collective weight of evidence was that carbaryl is not a carcinogen.

Although carbaryl itself may not be a carcinogen, there is still uncertainty about cancer risk associated with carbaryl because of its ability to combine with nitrite ions to form N-nitrosocarbaryl. It is thought that oral exposre to N-nitrosocarbaryl results when carbaryl (as a residue in food) and sodium nitrite (in saliva or food) combine in the stomach under acid conditions. In studies with guinea pigs, the formation of N-nitrosocarbaryl was reported when sodium nitrite and carbaryl were present in the stomach (Rickard and Dorough 1979). However, the in vivo yield (in the stomach) was less than 0.2 percent of that obtained in the test tube (in vitro).

The cancer potential of N-nitrosocarbaryl has been studied by feeding rats N-nitrosocarbaryl directly by gavage. Lijinsky and Taylor (1976) reported a high incidence (75 percent) of tumors of the forestomach in female rats given a total dose of 50 mg during a 10-week period of time. Only 47 percent of the male rats had tumors of the forestomach resulting from a total dose of 5,000 mg. However, they reported that treated animals had a shorter life span (compared to controls) which was due to the high cumulative toxicity of N-nitrosocarbaryl and the early appearance of tumors. Lijinksy and Schmahl (1978) repeated the study reported in Lijinsky and Taylor (1976) and found that 57 percent of the female rats had tumors of the forestomach resulting from a total dose of 600 mg/kg given over a 10-week period of time. These studies all conclude that N-nitrosocarbaryl is a locally acting potent carcinogen when administered orally, but the potency is uncertain because of the erratic tumor results reported in the literature.

The uncertainty of cancer risk to humans resulting from N-nitrosocarbaryl (as a result of exposure to carbaryl) is further compounded by the fact that direct administration of carbaryl and nitrite to rats failed to result in any tumors (Lijinsky and Taylor 1977). Also, a number of studies have reported that vitamins C and E, normal components of human diets, effectively block the synthesis of nitrosamines* under conditions found in the stomach (Fan and Tannenbaum 1973a, 1973b, and Fiddler et al. 1973). However, to assess the risk of cancer to humans, this analysis assumes as a worst-case that nitrosocarbaryl would form in the stomach of humans with a subsequent carcinogenic potential.

Since no carcinogenic potency values for N-nitrosocarbaryl were available in published literature, they were determined using a simple linear model for cancer incidence modified from Crouch and Wilson (1979) as follows:

$$R = a + Bd$$

Where:

R = the probability of incidence of cancer
a = the spontaneous incident rate; (incidence in untreated control animals)
B = the cancer potency
d = the lifetime dose of the test animal in mg/kg/day.

This model assumes that the lifetime probability (R) of an animal getting cancer depends on the integrated lifetime dose of the carcinogen. The lifetime dose can be ingested at a constant rate or a nonconstant rate, although it must be averaged over the lifetime of the animal.

This analysis assumes that an animal carcinogen is a human carcinogen. Thus, the cancer potency value from animal tests must be extrapolated to humans. As noted in Section 2.1, when dose is measured on a body weight basis, humans are often 6 to 12 times more sensitive to chemical effects than animals. Extrapolations to humans are made using the following formula.

$$R \text{ (in humans)} = B \times K \times d$$

Where:

R = the probability of incidence of cancer
B = cancer potency in the test animal
d = lifetime dose for humans
K = an interspecies correction factor (multiplier)

The multiplier (K) is applied to account for differences in sensitivities between species. This factor is intended to correct for such things as differences in metabolism between species and differences in routes of exposure or food consumption. It is also important to note that cancer potencies are first determined from animals that have been bred for their sensitivity to express specific cancers. Potencies from these sensitive animals are then extrapolated to humans to cover the possibility of all types of cancer. Obviously, there is considerable uncertainty involved with such extrapolations.

Mantel and Schneiderman (1975) note that when doses are calculated on the basis of dose weight per unit of body surface area, (mg per square centimeter) the differences between species can be minimized. A correction factor based on this similarity can provide first approximation for extrapolating between species. Since surface area is proportional to body weight to the two-thirds power ($wt.^{2/3}$), the multiplier K of:

$$K = (\text{wt. human/wt. animal})^{1/3}$$

will adjust the cancer potencies (B) for differences in surface area to body weight ratios (Mantel and Schneiderman 1975). Depending on the weight of the test animal, this correction factor will increase the apparent cancer potency for humans by 5 to 14 times over the animal rates. This is the same correction factor used by EPA (Crouch and Wilson 1979).

Using these assumptions and the linear (no threshold) model for cancer, the cancer potency in humans of N-nitrosocarbaryl ranges from 0.06 to 7.6 (mg/kg/day), depending upon which cancer study is used in the calculation. The calculations of cancer potency of N-nitrosocarbaryl are in Attachment A, Section A-1. For this analysis, the average value of 3.6 per (mg/kg/day) was used which excluded the results of Eisenbrand et al. (1976) because they reported more deaths resulting from the toxicity of the high dose of N-nitrosocarbaryl than resulted from tumors. Including the Eisenbrand data would lower the cancer potency.

3. ANALYSIS OF EXPOSURE AND DOSE FOR AFFECTED POPULATIONS

This section determines the exposure and subsequent dose to workers involved in herbicide application as well as to the general public.

An important distinction should be made between exposure to pesticides and subsequent dosage. Exposure refers to the contact or potential contact between the chemical compound and the surface of the organism prior to incorporation of the chemical into cells or organs. The dose refers to the portion of the substance that is taken into the organism as a result of exposure. Exposure to herbicides during application is often a function of physical variables such as spray equipment, wind speed, height of application, and concentration of herbicide applied. The dose or amount absorbed from an exposure often depends on the chemical characteristics of the herbicide. For example, the dermal dose will be a function of the nature of the chemical and its interaction with skin surfaces.

3.1 Worker Exposure and Dose

Haverty et al. (1983) report both drift and worker exposure from the application of insecticides to pine trees with high-pressure hydraulic sprayers and hand-held spray nozzles. This spray system is used in Region 1 to protect selected trees from mountain pine beetle attack.

The Haverty study measured the spray deposition to various body parts of workers applying the spray to individual trees. Total deposit onto face, neck, arms, and hands averaged 0.74 mg for each tree sprayed (calculation in Attachment A, Section A-2). Typical applicators would wear long-sleeved shirts and gloves. Assuming only exposed skin on the face and neck of applicators, the average deposit on bare skin would be 0.042 mg for each tree sprayed (calculation Attachment A, Section A-2).

Calculation of the worker dose requires an estimate of the percentage of spray deposit that will be absorbed through the skin. Estimates of the dermal absorption of carbaryl range from 1 percent to about 75 percent. Feldman and Maibach (1974) reported a 73.9 percent dermal absorption rate of carbaryl when the insecticide was administered to humans in an acetone solution. This estimate is probably very high. When this absorption rate is used with measurements of worker exposure to estimate worker dose in cases where direct measures of worker dose (via urinalysis) are available the dermal adsorption rate of 73.9 percent becomes suspect. As noted on pages F-29 and F-30 of the risk analysis contained as Appendix F in the Gypsy Moth Suppression and Eradication Projects: Final Environmental Impact Statement as Supplemented - 1985, calculations of dose to observers who were merely on site during spraying would predict doses five times higher than dose actually measured in workers directly involved in the mixing and loading of pesticides.

On this basis dermal absorption rates of 10 percent and as low as 1 percent can be defended. The higher absorption figure measured by Feldman and Maibach (1974) may be in part a function of the acetone solvent used as a carrier. By contrast, operational spray mixtures are water based. Likewise, it is not known at what point spray deposition saturates the skin such that a constant amount is absorbed irrespective of how much more spray is deposited. Because of the uncertainty involved in predicting dermal absorption rate, worker dose will be calculated using a range of dermal adsorption values--1 percent, 10 percent, and 75 percent.

Worker values are calculated for a low protection scenario and a typical protection scenario. The low protection scenario assumes that the worker wears a sleeveless shirt and no gloves. The typical protection scenario assumes long-sleeved protective gear and gloves (as is typical in Forest Service projects). Under each of these scenarios, an average-dose value and a high-dose value are provided. The average value is based on the average spray deposition values measured by Haverty et al. (1983). The high values were calculated by adding two standard deviations of the average values. It can be expected that at least 98 percent of worker doses would be below these high values provided that the other assumptions regarding dermal absorption and protection scenarios are applicable.

The worker doses provided do not include an explicit contribution from inhalation exposure. By measuring the quantities of herbicide impinging on respirator filters, Lavy et al. (1982 and 1980) have demonstrated that the dose from inhalation is negligible (less than 1 percent of the dose from dermal exposure provided dermal absorption rates are above 1 percent).

Table 2 provides worker dose estimates from spraying one tree and Table 3 provides estimates of worker daily doses based on an assumption of 100 trees sprayed per day. As summarized on Table 3, predicted worker daily dose varies from a low value of 0.00006 mg/kg to a high value of 0.544 depending on the assumptions used in the analysis (see Attachment A, Section A-2) for calculations).

Table 2.--Worker dose estimates from spraying one tree (dose in mg/kg).

	1 percent dermal absorption	10 percent dermal absorption	75 percent dermal absorption
Normal protection scenario			
Average dose	0.0000006	0.000006	0.000045
High dose	0.0000032	0.000032	0.00024
Low protection scenario			
Average dose	0.0000106	0.000106	0.000795
High dose	0.0000726	0.000726	0.00544

Table 3.--Worker daily dose estimates from spraying 100 trees in a day (dose in mg/kg).

	1 percent dermal absorption	10 percent dermal absorption	75 percent dermal absorption
Normal protection scenario			
Average dose	0.00006	0.0006	0.0045
High dose	0.00032	0.0032	0.024
Low protection scenario			
Average dose	0.00106	0.0106	0.0795
High dose	0.00726	0.0726	0.544

Some spray projects may have supervisors on sites. Data is not available to estimate a supervisor dose except to say that it would be less than the sprayer's dose. The following section on possible doses to the general public will include estimates of observers on site.

3.2 General Public Exposure and Dose

The general public could be exposed to pesticides by direct contact with spray drift and spray-contaminated vegetation, and consumption of spray-contaminated vegetation, water, or wild game. Each of these exposure pathways is considered in this analysis.

3.2.1 Direct Dose from Drift and Dermal Contact with Spray-Contaminated Vegetation.

Haverty et al. (1983) have shown that the drift fallout from hydraulic spraying of pine trees was virtually nondetectable beyond 40 feet from the sprayed tree. For this reason, drift impacts onto residences and facilities beyond one-quarter mile can be safely assumed to be essentially zero.

Although spray sites will be closed to the general public, it is possible that a person not involved in the spraying could wander into the area. The South Carolina Epidemiologic Studies Center (SCESC) (1978 and 1979) determined the exposure and dose for various worker groups and nearby residents during aerial application of carbaryl. Although most worker functions and exposures during aerial application differ significantly from exposures during applications analyzed here, the doses measured by SCESC (1978, 1979) for project "observers" (inspectors, scouts, rangers, and ecologists) would provide high estimates of doses to persons in the vicinity of these projects. The projects investigated by SCESC (1978, 1979) involved much higher application amounts and higher off-target impacts. The doses measured in project observers includes both exposure from drift and dermal exposure to drift-contaminated vegetation.

In the SCESC studies, the carbaryl doses were measured directly by analyzing for 1-naphthol (a major metabolite of carbaryl) in the urine. The 1-naphthol excreted in urine was converted to carbaryl dose by multiplying the 1-naphthol residue level by 3, and by average urine excreted. The multiplier 3 was used because the Union Carbide Corportaion found that 32.8 percent (1/3) of the cumulative carbaryl dose is excreted as 1-naphthol during the first 12 hours (sampling period in the tests) (SCESC 1978). The average amount (milligrams) of carbaryl excreted is converted by dividing by 70 kg (the average body weight of a human). The average carbaryl dose is estiamted to be 0.001 mg/kg/day for an observer in the close vicinity of spraying. Worst-case doses were estimated by adding two standard deviations to average dose values. (This is equivalent to setting the upper worst-case value at the 95 percent confidence limit). The worst-case carbaryl dose for observers is estimated to be 0.009 mg/kg/day for observers or general public in the vicinity of spraying.

The data on project observers studies is summarized below:

Number of observer samples	Average 1-naphthol (ppm)	Standard deviation (ppm 1-naphthol) excreted	Average observer carbaryl dose (mg/kg/day)	Worst-case observer dose (mg/kg/day)
59	0.04	0.16	0.001	0.009

3.2.2 Oral Doses

There exists a possibility, although slight, that a visitor to the spray area could collect and eat spray-contaminated wild food. The spray areas would be closed and posted for a week after spraying. In addition, typical wild foods frequently collected in this Region (e.g., huckleberries) would not ripen for a minimum of 2 weeks and more likely in excess of 1 month after spraying.

The tolerance level established by the EPA for marketing blueberries and strawberries is 10 ppm. Application of 1 to 2 pounds of carbaryl per acre can be made 1 day before picking without exceeding this tolerance (Union Carbide 1968). One to 2 pounds active ingredient carbaryl per acre is the usual dose for commercial crops of these berries. Carbaryl residues on these crops decrease rapidly (Fahey et al. 1962). Strawberries sprayed for the third time and with 1 pound active ingredient had residues of 1.1 ppm 1 day after spraying to 0.3 ppm 4 days after spraying.

Assuming that an adult consumed a half pound (0.25 kilograms) of wild fruit containing 0.3 ppm (mg/kg) of carbaryl residue, the dose to a 70 kg person would be 0.001 mg/kg (0.25 kg x 0.3 mg/kg x person/70 kg). As a worst-case assumption, a concentration of 1.1 ppm can be assumed, resulting in a dose of 0.004 mg/kg.

There is only a small possibility of secondary carbaryl dose to humans from consuming wild game that has grazed on spray-contaminated vegetation or has been exposed to drift or drift-contaminated vegetation. Hunting season does not begin for several months after spraying. Because the spray areas are very small (10 acres or less) and the lodgepole pine being treated contain little forage for game animals, the possibility of animal exposure to the pesticide is small.

There are no data available documenting the amounts of carbaryl in food animals that might be in areas treated for mountain pine beetle. There are; however, a number of studies documenting pesticide levels in animal tissue, milk, or eggs resulting from direct application to animals for insect control purposes. For example, carbon 14 (C^{14}) labeled carbaryl fed to cattle in doses of 0.25 and 3.05 mg/kg resulted in radiolabeled residues in milk equivalent to 0.35 percent of each dose (Dorough (1967). Maximum concentrations of carbaryl-C^{14} equivalents (a total of all metabolites) of 0.06 ppm and 0.95 ppm were found in milk 6 hours after administering the 0.25 and 3.05 mg/kg doses, respectively. Analysis of 27 tissues (muscle, organs, or parts thereof) sampled 6 days after the high dose showed only trace amounts of residues (about .0003 mg/kg based on the radioactive counts). Claborn et al. (1963) reported finding carbaryl residues in the muscle of cattle, sheep, goats, and hogs that ranged from less than 0.04 to 0.18 mg/kg when the animals were sprayed four times in a 2-week period. Residues were all below the detection limit within 7 days after the treatments were concluded. These studies show that deer or rabbits may have residues in their edible tissue that could range from nondetectable (less than 0.003 mg/kg) up to 0.045 mg/kg if the animals were exposed to 0.2 to 3 mg/kg of carbaryl (the range of exposure to animals estimated in this analysis (as shown in Attachment A, Section A-3). Assuming that an individual eats 0.5 kg of this meat daily, the dose to a 70 kg person would range from 0.00002 (realistic) to 0.0003 mg/kg/day (worst-case).

A minimum buffer of 50 feet would separate spray areas from water. Section 5 examines the possible effects of a misapplication of pesticide to water. Under normal circumstances, concentrations in water could not be detected in water even at 50 feet from the spray area. For example, Haverty et al. (1983) showed that at 12 meters (37 feet) from trees sprayed with hydraulic sprayer, the worst-case drift deposition onto surfaces was 0.2 micrograms per square centimeter (mean value plus 2 standard deviations). Assuming water only 6 inches (15 centimeters (cm)) deep, the concentration in water would be 0.013 milligrams/liter (0.2 microgram/15 cm^3 x 1,000 cm^3/liter x 1 milligram/1,000 micrograms). The dose to a 70 kg person who drank 2 liters of water at this concentration would be 0.0004 mg/kg.

Table 4 summarizes realistic and worst-case doses for members of the general population for various possible exposure pathways. It should again be emphasized that even doses listed as "realistic" on Table 4 depend on low probability scenarios such as the consumption of wild berries which are not generally available for a period after spraying or the poaching and consumption of wild game that has fed fairly exclusively on spray-contaminated forage.

Table 4.--Dose estimates to members of the general public.

	Realistic estimate (mg/kg/day)	Worst-case estimate (mg/kg/day)
Dose from drift and dermal contact with sprayed vegetation	0.001	0.009
Oral dose - sprayed wild food	0.001	0.004
Oral dose - meat	0.00002	0.0003
Oral dose - water	Not calculated[1]	0.0004

[1]Realistic doses not calculated because buffer strip will protect water under normal circumstances.

4. EVALUATION OF RISK

The realistic and worst-case risk expectations (both short-term and lifetime) can now be defined by comparing the assumed dose levels with levels identified as hazardous or safe in animals and man. Human Acceptable Daily Intake (ADI) of 0.1 mg/kg/day has been established for carbaryl by EPA, and is based on a 2-year rat feeding study with a NOEL of 10 mg/kg/day and a safety factor of 100 for extrapolation from animals to humans (USDA, 1985). The lowest NOEL established in laboratory testing is based on indicators of teratogenicity in dogs. ADI and the lowest NOEL (as identified in Table 1) are compared to the realistic and worst-case doses in order to evaluate the risk for nongenetic responses such as teratogenicity (birth defects), fetotoxicity, and systemic toxicity (such as cholinesterase inhibition, liver dysfunction, reduced fetus and organ weight, food consumption, or blood chemistry). This provides a straight-forward method for evaluating the overall health risks. For example, a dose that is equal to or below the ADI can be said to be within an acceptable margin of safety (Doull et al. 1980). Where realistic and worst-case doses exceed the ADI, a comparison with the NOEL is made to determine the risks of specific effects such as cholinesterase depression or birth defects, etc. In addition, the relationship between the dose levels estimated in Section 3 and dose levels which have shown some evidence of renal effects in human studies (see Section 2.2.1) is dicussed.

4.1 Adverse Effect Threshold Comparisons for the General Public

Table 5 compares various dose estimates for the general public with the NOEL and ADI values for carbaryl. General public exposure scenarios include dose that results from the direct application of the insecticide, and a combination of direct application and dietary doses. The calculated realistic and worst-case doses are compared to the lowest NOEL or ADI* by calculating the ratio of NOEL/dose and ADI/dose. If the dose is less than the NOEL or ADI, the comparison ratio is greater than 1.0. If the dose is greater than the ADI or the NOEL, the comparison ratio is less than 1.0. All doses and combinations of doses to the general public both realistic and worst case, are below the lowest NOEL and the ADI value set by EPA. In addition, all doses and combination of doses are below levels that have been shown to have any reversible effects on kidney function in human tests.

Table 5.--Relationship of general public dose estimates to established dose thresholds for carbaryl.

	Realistic			Worst case		
Exposure scenario	Expected dose (mg/kg/day)	Relationship to established threshold* ADI	NOEL	Expected dose (mg/kg/day)	Relationship to established threshold ADI	NOEL
General Public						
Drift (on site)	0.001	100	3,725	0.009	11	414
Drift (on site) and Dietary	0.00202	50	1,844	0.0137	7	272
Dietary only	0.00102	98	3,652	0.0047	21	793

*ADI = 0.1 mg/kg/day and NOEL = 3.725 mg/kg/day.

Positive numbers indicate the number of times the expected dose is below the established ADI and NOEL. Negative numbers would be the number of times the expected dose is above established ADI and NOEL.

The issue of teratogenicity* or birth defects is often raised by the public when human health effects associated with exposure to chemicals are being evaluated. The teratogenicity issue generates a great deal of emotion and is appropriate for further discussion here. The NOEL value used in Table 5 as a point of comparison is based on a study of the teratogenic and fetotoxic effects of carbaryl in dogs. As reviewed in Table 1, dogs are the test animals most sensitive to carbaryl and indications of safe levels of human exposure are based on the most sensitive species tests. The NOEL/dose comparison on Table 5 indicate that the teratogenicity NOEL is more than 250 times higher than the highest worst-case combination of doses.

As discussed in Section 2.1, safety factors are required to protect the sensitive individuals in a population (old, young, weak, debilitated) as well as account for the uncertainty of data extrapolation from animals to humans (intraspecies variation). Traditionally, the intraspecies variation in response to toxic substances has been accounted for by a factor of 10 (Doull et al. 1980 and Dourson and Stara 1983).

There are individuals or groups of people within the general population whose response to carbaryl will be greater than the general public. In other words, adverse health effects might occur in these sensitive populations at doses much lower than those causing impacts to the general public. Common examples of this difference in sensitivity within the general population are individuals who are sensitive to pollen, poison oak or ivy, bee stings, or penicillin. Cases of severe hypersensitivity are rare (Ottoboni 1984), and it is impossible to identify a specific percentage of the population that would fall within the sensitive population (Calabrese 1978).

In order to minimize or eliminate possible reproductive impacts on sensitive individuals, the NOEL/dose comparisons should indicate safety factors of 100 or greater. The ADI based on general toxic effects already includes a safety factor (100 in this case) which was incorporated, in part, to account for differential responses within the population. Although the safety factor of 100 is arbitrary, it is based on a review of selected literature on variable human responses to foreign chemicals (xenobiotics) or diseases (NAC-NRC 1977, Glowinski et al. 1978, LaDu and Eckerson 1984, Kersey et al. 1974, Tabershaw and Cooper 1966, and Calabrese 1984).

By virtue of the fact that all NOEL/dose comparisons for the general public exceed 100 and all general public doses are below the ADI for carbaryl. The general public including sensitive populations should suffer no adverse impacts from carbaryl application to control mountain pine beetle.

4.2 Adverse Effect Threshold Comparisons for Workers

Table 6 compares various worker dose estimates (based on 100 trees sprayed daily per worker) with the NOEL and ADI values for carbaryl. All normal protection scenario doses are below the ADI and the NOEL values. This includes normal protection scenario doses based on an assumption of 75 percent dermal absorption rate for carbaryl. All normal protection scenario doses are below the levels that have been shown to have reversible effects on kidney functions in human tests.

Table 6.--Relationship of daily dose estimates for workers to established threshold for carbaryl.

Exposure scenario	Dose (mg/kg/day)	Relationship to established threshold[3] ADI	NOEL
Normal protection scenario			
1 percent[1]			
Average dose[2]	0.00006	1,667	62,083
High dose	0.00032	312	11,641
10 percent			
Average dose	0.0006	167	6,208
High dose	0.0032	31	1,164
75 percent			
Average dose	0.0045	22	828
High dose	0.024	4.2	155
Low protection scenario			
1 percent			
Average dose	0.00106	94	3,514
High dose	0.00726	14	513
10 percent			
Average dose	0.0106	9.4	351
High dose	0.0726	1.4	51
75 percent			
Average dose	0.0795	1.3	47
High dose	0.544	Above[4]	6.8

[1] 1 percent, 10 percent, and 75 percent refer to estimates of dermal absorption. See Section 3.1 for discussion.

[2] Average doses are based on average exposures from Haverty et al. (1983). High doses are based on average doses plus two standard deviations. See Section 3.1 for discussion.

[3] ADI = 0.1 mg/kg/day and NOEL = 3.725 mg/kg/day.

[4] Dose is above the ADI (about five times higher than the ADI).

Most low protection scenario doses are below NOEL and ADI values for carbaryl. Exceptions would only occur in the event of high exposure with little protective clothing and a carbaryl dermal absorption rate of 75 percent. As discussed in Section 3.1, a carbaryl dermal absorption rate of 75 percent is considered unlikely. Both average and high doses assuming a 75 percent dermal absorption and high doses assuming a 10 percent dermal absorption rate approach or are above doses that have had minor reversible effects on kidney functions in humans.

Additional consideration of the issue of teratogenicity is also appropriate particularly since women can work on spray crews. Once again, the analysis indicates that application techniques and use of personal protective clothing can insure safety factors greater than 100. Safety factors fall below 100 where little protective clothing and high dermal exposure combine with high estimates of dermal absorption rate. As safety factors fall below 50 as in several scenarios outlined above, the possibility of adverse impacts increase.

In summary, if all worst-case assumptions are met, i.e., 75 percent dermal absorption of excess exposure to carbaryl and low personal spray protection, affected workers could experience some negative health effects. These effects could include minor reversible impacts on kidney function and a reversible increase in cholinesterase inhibition and under worst-case conditions, the small possibility of impacts on pregnant females. The obvious symptoms, under these extreme circumstances, could include some dizziness, nausea, and other manifestations summarized in the beginning of Section 2 of this analysis.

Under typical Forest Service spray conditions using recommended protective gear including long-sleeved protective clothing and gloves, worker doses should be below adverse effect levels that could cause significant cholinesterase inhibition, effects on kidneys, or reproductive effects on females.

4.3 Nonthreshold Impacts from Carbaryl Dose

4.3.1 Carcinogenicity

As discussed in Section 2.2.6, the formation of N-nitrosocarbaryl from carbaryl and possible carcinogenic effects on exposed humans are assumed in this analysis. Only oral doses of carbaryl will be considered in the formation of N-nitrosocarbaryl because the compound is assumed to be formed by the reaction of carbaryl and nitrite ions in the stomach. The N-nitrosocarbaryl dose can be calculated from the oral carbaryl doses as follows:

N-nitrosocarbaryl dose = carbaryl dose x (230/201) x 0.002

Where:

(230/201) = molecular weight of N-nitrosocarbaryl divided by the molecular weight of carbaryl, which assumes that all of the carbaryl would be converted to nitrosocarbaryl.

0.002 = the *in vivo* yield compared to theoretical yield (Rickard and Dorough 1979)

As discussed in Section 2.2.6, the expected probability of cancer caused by exposure to carbaryl and subsequent formation of nitrosocarbaryl is determiend using the following equation:

$$R = B_h d$$

Where B_h is the cancer potency for humans in $(mg/kg/day)^{-1}$ and d is the average lifetime dose, (mg/kg/day) (Crouch and Wilson 1979 and Crouch et al. 1983).

Since exposure to carbaryl resulting from its use in mountain pine beetle suppression projects does not occur daily over a 70-year lifetime, the lifetime average dose must be calculated based on the cumulative number of projects in a lifetime, number of days exposure during each project, and amount of exposure during each of those days. Average lifetime oral dose (d) of carbaryl is calculated as follows:

$$d = (d_i + d_1 + d_2 + \ldots d_f) \times E/25{,}550$$

Where d_i = dose received the day of spray
d_1 = indirect dose 1 day after spray
$d_2, d_3 \ldots d_f$ = indirect dose levels, 2, 3, or f days (insecticide dissipates) after spray
E = number of applications per lifetime (2 is assumed)

25,500 = number of days in a 70-year lifetime.

Average lifetime dose values for carbaryl and N-nitrosocarbaryl are calculated in Attachment A, Section A-4. Average lifetime doses of N-nitrosocarbaryl are 2.0×10^{-10} mg/kg/day for realistic exposures and 1.5×10^{-9} mg/kg/day for worst-case exposures.

The cancer risk to an individual exposed to realistic or worst-case dietary doses of carbaryl for mountain pine beetle suppression projects is then calculated using the lifetime average realistic and worst-case doses (d) of 2.0×10^{-10} and 1.5×10^{-9} mg/kg/day.

$$R \text{ (risk)} = B_h d = 3.6 \text{ per (mg/kg/day)} \times d$$

For realistic doses:

$$R = 3.6 \text{ per (mg/kg/day)} \times 2.0 \times 10^{-10} \text{ mg/kg/day}$$
$$= 7.2 \times 10^{-10} \text{ or a risk of about seven in ten billion.}$$

For worst-case doses:

$$R = 3.6 \text{ per (mg/kg/day)} \times 1.5 \times 10^{-9} \text{ mg/kg/day}$$
$$= 5.4 \times 10^{-9} \text{ or a risk of about five in a billion.}$$

The assessed risk of cancer that could occur from using carbaryl to control mountain pine beetle is only meaningful to the decisionmaker or other readers if it can be compared to similarly determined risks for known cancer-causing agents (such as x-rays or smoking) or other risks of death. Some risks are so small that people tend to ignore them because they are unconsciously accepted (e.g., crossing a street). For example, many risks of 10^{-6} per year (one chance in a million) are familiar and casually accepted by the general public. Weighted lifetime risks of cancer to an individual exposed to carbaryl can be compared to a number of risks familiar to society which are listed in Table 7 taken from Crouch and Wilson (1982). The cancer risks shown in Table 7 were calculated by a method similar to that used in this analysis; thus the same uncertainties dealing with exposure, measurements of potency, and extrapolation between laboratory animals and humans apply. In all cases, the lifetime risks of cancer resulting from exposure to carbaryl are lower than the risk of cancer from smoking two cigarettes, drinking 40 diet sodas, or having a single x-ray in a lifetime, which are all in the order of 10^{-6} or one in a million risk.

Cancer risk in the use of carbaryl is obviously a major concern; although the project decisionmaker must establish a frame of reference in evaluating the magnitude of this risk.

Table 7.--Lifetime risk of death or cancer resulting from every-day activities.[1]

Activity	Time to accumulate a one-in-a-million risk of death	Average annual risk per capita
	Living in the United States	
Motor vehicle accident	1.5 days	2×10^{-4}
Falls	6 days	6×10^{-5}
Drowning	10 days	4×10^{-5}
Fires	13 days	4×10^{-5}
Firearms	36 days	1×10^{-5}
Electrocution	2 months	5×10^{-6}
Tornados	20 months	6×10^{-7}
Floods	20 months	6×10^{-7}
Lightning	2 years	5×10^{-7}
Animal bites or stings	4 years	2×10^{-7}

Occupational Risks

General		
manufacturing	4.5 days	8×10^{-5}
trade	7 days	5×10^{-3}
service and government	3.5 days	1×10^{-4}
transport & public utilities	1 day	4×10^{-4}
agriculture	15 hours	6×10^{-4}
construction	14 hours	6×10^{-4}
mining and quarrying	9 hours	1×10^{-3}
Specific		
coal mining (accidents)	14 hours	6×10^{-4}
police duty	1.5 days	2×10^{-4}
railroad employment	1.5 days	2×10^{-4}
fire fighting	11 hours	8×10^{-4}

One-In-A-Million Risks of Cancer

Source of risk	Type and amount of exposure: examples
Cosmic rays	One transcontinental round trip by air; living 1.5 months in Colorado compared to New York; camping at 15,000 feet over 6 days compared to sea level.
Other	20 days of sea level natural background radiation; 2.5 months in masonry rather than wood building; 1/7 of a chest x-ray using modern equipment.
Eating & drinking	40 diet sodas (saccharin) 6 pounds of peanut butter (aflatoxin) 180 pints of milk (aflatoxin) 200 gallons of drinking water from Miami or New Orleans 90 pounds of broiled steak (cancer risk only)
Smoking	2 cigarettes

[1] From Crouch and Wilson (1982)

4.3.2 Mutagenicity*

Since there is no available epidemiological* data demonstrating an association between chemical exposure and heritable mutations, the extent that exposure to natural or synthetic chemicals may increase the number of heritable mutations in the present population is unknown at this time. Therefore, the experimental evidence presented in the Review of Toxicology section indicates only the absence or presence of mutagenic capability, no quantification. Carbaryl is a weak mutagen, but no increase in the rate of spontaneous mutations is expected from the use of carbaryl. This conclusion is based on the cancer risks associated with carbaryl. Since mutagenicity and carcinogenicity both follow similar mechanistic steps (at least those that involve genetic toxicity), the increased risk of cancer can be used to approximate the quantitative risk of heritable mutations. The basis for this assumption is that both mutagenicity and at least primary carcinogens react with DNA to form a mutation, or DNA lesion, affecting a particular gene or set of genes.

The genetic lesions then require specific metabolic processes to occur or the cells must divide the lesion into the genetic code of the cell. We believe the cancer risk provides a worst-case approximation to heritable mutations because cancer involves many types of cells whereas heritable mutations involve only germinal (reproductive) cells. Therefore, the worst-case risk of heritable mutations is less than one chance in 100 million.

4.4 Synergism/Cumulative Effects

To complete this analysis, the possible interaction of this insecticide with other chemicals in the environment and the cumulative effects from the same insecticide already in the environment from other sources is discussed. Synergism is a special type of interaction where the combined effect of a specific insecticide with one or more chemicals in the environment (such as pollutants) would be greater than the sum of the individual effects of the insecticide and chemical(s) (in other words, 2 + 2 is greater than 4). Since we live in a sea of chemicals, the possibility of chemical/insecticide interaction is certainly probable. However, because of the complex number of possible interactions, the result is not readily predictable.

A good measure of whether synergistic or cumulative effects or any total human health affects occur are epidemiological studies on exposed populations. The New Jersey State Department of Health, Parental, and Child Health Services (Halpin 1980) conducted an epidemiology study investigating the relationship between birth defects and carbaryl spraying in areas of New Jersey treated for gypsy moth control. They found no association between spraying of carbaryl and birth defects.

Since the dose or concentration of any chemical dictates both the probability and rate of any chemical reaction (and all biological responses in an organism are the result of chemical reactions), the dose of the specific insecticide in the environment or in the individual is an important factor in considering synergistic effects. Ames (1983) pointed out that there are many naturally occurring chemicals in the food people eat which are teratogenic, mutagenic, and carcinogenic, and which are consumed at doses 10,000 times higher than man-made pesticides. Therefore, the low, short-lived doses that result from the spraying of these insecticides to control mountain pine beetle is very small compared to many other chemicals in the environment. For these small comparative doses, a synergistic effect is not realistically expected (Crouch et al. 1983). EPA apparently came to the same conclusion, because they issued a Notice (PR Notice 82-1) on January 12, 1982 (U.S. EPA 1982), rescinding the requirement for submission of tank mix compatability data. The Notice stated that EPA had examined considerable data and found no evidence of potentiation involving pesticides.

However, Statham and Lech (1975a, 1975b, and 1976) have reported the potentiation or synergistic effect of carbaryl on the acute toxicity of 2,4-D, dieldrin, rotenone, and pentachlorophenol. The acute toxicity of these latter pesticides were increased by factors of 3- to about 8-fold with additions of 1 mg/liter (1 ppm) of carbaryl. Keplinger and Deichman (1967) studied the effect of pesticide combinations on LD_{50} values. They reported that carbaryl induced less than additive effects when combined with the chlorinated hydrocarbon pesticides, but it induced more than additive (about 1.5-fold) increases of the LD_{50} values for the organic phosphates.

The authors did not consider this small increase as an indicator of synergism. Since the Statham and Lech, and Keplinger and Deichman studies dealt with concentrations that are higher than would be expected from the use of carbaryl for mountain pine beetle, the synergistic effects could be considered to be worst case. However, a synergistic response similar to the interaction of tobacco smoke and asbestos in humans was used for the worst case in this analysis.

Smokers who were also exposed to asbestos have an 8-fold higher risk of lung cancer than smokers alone (Selikoff et al. 1968). If a 10-fold synergistic factor were applied to the NOEL/dose comparisons and cancer risk values developed in this analysis, cancer risks would still be less than the one-in-a-million level. Except for some low protection scenarios in workers, all teratogenicity thresholds would still exceed even the worst-case dose levels by factors that have traditionally been accepted as safe.

A nearby resident who uses carbaryl on his own garden illustrates one source of exposure in addition to that resulting from mountain pine beetle suppression. Other major sources of exposure include food consumption or drift for those individuals who live near or adjacent to agricultural areas where carbaryl is used. To fully discuss cumulative effects, the total dose from all sources would need to be calculated. Since this is impossible, cumulative effects can only be discussed in general terms.

In one example (USDA, 1985) the 1-naphthol residue (2,556 ppb) in the urine of the resident who used carbaryl on his garden shows that doses of 0.01 mg/kg/day are possible from such uses. Food tolerances for residues of carbaryl (0.2 to 12 ppm) show that oral doses could range from 0.007 to 0.07 mg/kg/day (based on the assumptions used in this analysis) if food containing the maximum tolerance was eaten. Such dose levels are equal to or greater than those estimated to result from the use of these insecticides for pine beetle control, but the cumulative doses would be below the ADI in all but a few worst-case situations.

Data gathered by the Food and Drug Administration (USDA,1985) show that high accumulations of residues of carbaryl have not occurred from eating meats, fruits, and vegetables that have been treated with this insecticide. Residues for carbaryl on food collected since 1978 indicate a daily dietary intake of 0.00001 to 0.00005 mg/kg/day. Since carbaryl is used on more crops than most other insecticides, the 0.00005 mg/kg/day residue level can be assumed to be an upper limit of accumulation of these insecticides from agricultural uses. This value is 20 times below the lowest dietary value of 0.001 mg/kg/day used in this analysis. Therefore, there should be little, if any, cumulative effect from this source.

5. WORST-CASE ACCIDENTAL EXPOSURES

Worst possible exposures to humans, animals, or fish can result from accidental events such as large spills. These spills may occur at the mixing/loading site or on other lands or into potable water sources. In this analysis, the exposure levels and subsequent doses identified are based upon worst-case assumptions for trucking accidents. The size of the spill and the resulting impact depends on many variables such as size of insecticide load in gallons, distance to water, stream size, and density of human or animal population. Transportation of pesticides could result in spills of up to 80 lbs. active ingredient of pesticide.

In evaluating truck spills, only rapid spills on land and in water were considered. Slow, hose-type leaks release small amounts of insecticide and can be controlled quickly by project personnel. As a result, the potential for exposure to such spills is much lower than that possible with larger spills. For this analysis, it is assumed that occupational exposure is the same for large or small spills since mixer/loader/drivers would be involved with the initial containment and cleanup. Furthermore, it is assumed that potential exposure to bystanders from such spills would not exceed that of workers without protective equipment initially involved in the cleanup.

If the spill is directly into a stream, the mean 24-hour concentration level, or MC (24), in ppb can be calculated using the following equation (USDA Forest Service 1984):

$$MC\ (24) = 185 \times \text{lbs of insecticide/cfs}$$

To simplify calculations, it is assumed that all of the spilled insecticide (80 pounds active ingredient) would land in the stream flowing at 15 cubic feet per second (cfs). Thus the MC (24) would equal 987 ppb or 0.987 mg/kg. It is interesting to note that an actual spill of 1,890 gallons into Willow Creek in eastern Oregon of carbaryl (4 lb/gal) mixed 1 to 1 with fuel oil resulted in carbaryl concentrations that ranged from 4.4 to 39.9 ppm at the site the day of the spill (USDA Forest Service 1983). Carbaryl concentrations dropped within the first 24-hour period to an average residue of 8.1 ppm.

If a 70 kg person drank 2 liters of water containing 0.987 mg/L of carbaryl, his dose would be 0.028 mg/kg. This dose is 132 times less than the teratogenicity NOEL and is about four times less than the ADI. This dose is also below the carbaryl dose level shown to cause minor reversible kidney misfunction in human tests.

The probability of cancer from such a dose can be calculated using the assumptions regarding N-nitrosocarbaryl formation and cancer potency presented in Section 4.3.1. N-nitrosocarbaryl dose would be 6.4×10^{-5} mg/kg (0.028 mg/kg $\times$ (230/201) x 0.002). Cancer probability would be about 9.0×10^{-9} (6.4×10^{-5} mg/kg/day x 3.6 per (mg/kg/day) x 1/25,550)) or about nine chances per billion.

Spills of carbaryl onto land have much less probability of causing widespread contamination than spills into flowing water systems. Carbaryl concentrate is carried in 5-gallon metal containers. It is possible that an accident could result in the rupture of a container. It was assumed that during cleanup a worker's hands and forearms were wetted to the point of runoff with pesticide concentrate. This amount was determined experimentally to be about 2 fluid ounces (using water as a surrogate). Thus, at 4 pounds active ingredient per gallon of concentrate, the worker would be exposed to about 28,350 mg of pesticide active ingredient (4 lb/gal x gal/128 oz x 2 oz x 453,600 mg/lb).

The dermal lethal dose (LD_{50}) to rats is reported to be greater than 4,000 mg/kg and the dermal LD_{50} for rabbits is greater than 5,000 mg/kg. The dermal exposure (as opposed to the actual dermally absorbed dose) given the spill assumptions above would be 304 mg/kg (28,350 mg x person/70 kg). While this dermal exposure would most likely not be fatal, it could result in symptoms of acute poisoning such as headache, dizziness, uncoordination, muscle twitching, nausea, abdominal cramps, diarrhea, or sweating within 12 hours of exposure. Carbamate insecticide poisoning is readily treatable with an antidote, atropine sulfate, in the event of an accident such as a spill or exposure to a worker.

The probability of a truck spill contaminating water is estimated to be 1.2×10^{-6} or one spill for every 833,333 vehicle trips of 100 miles each. Probabilities for spill incidents are taken from the 1984 Gypsy Moth Suppression and Eradication Projects FEIS (USDA FS/APHIS). The probability of a truck accident occurring and insecticide being released either on land or into water is calculated to be 1.08×10^{-5} or one insecticide spill for every 93,000 vehicle trips of 100 miles each. It can be assumed that approximately 6 spray projects a year in the Region could require about 500 miles of travel carrying pesticide. On this basis, the probability of a truck spill each year is one chance in 18,600 or a truck spill every 18,600 years. The probability of human contamination of the type outlined above cannot be calculated except to say that it is much smaller than the probability of a truck spill.

ATTACHMENT A

Derivations and Calculations Used in the Analysis

A-1. Cancer Potency Calculations

The dose response cancer model used in this analysis is a simple linear model modified from Crouch and Wilson (1979). It has the form:

$$R = a + Bd$$

Where a is the probability (risk) of getting cancer in the absence of a carcinogen (spontaneous cancer rate), d is the measure of dose (mg/kg/day) averaged over a lifetime, and B is the potency of the carcinogen. This model can only be used for low doses, where d is much less than (1- a/B).

The model contains the following assumptions:

1. The lifetime probability (R) of an animal getting cancer depends on the integrated lifetime dose of the carcinogen.

2. The relevant measure of dose is the ratio of the weight of the carcinogen to the body weight of the animal (mg/kg/day).

3. At high doses, the probability cannot exceed 1.0.

4. In animal experiments, the number of animals getting cancer is binomially distributed with probability P.

5. It is further assumed that a substance that causes cancer in test animals has the capacity to cause cancer in humans.

Following the suggestion of Mantel and Schneiderman (1975), cancer potency, expressed in terms of $(mg/kg/day)^{-1}$ for rats or mice can be extrapolated to humans by multiplying by the factor:

$$(\text{Human weight}/\text{animal weight})^{1/3}$$

Cancer Potency of N-Nitrosocarbaryl

There are three cancer studies using rats that can be used to calculate the potency of N-nitrosocarbaryl (Lijinsky and Taylor 1976, Eisenbrand et al. 1976, and Lijinsky and Schmahl 1978). All three studies used Sprague-Dawley rats force fed N-nitrosocarbaryl by the gavage* method of dosing. The results of the studies are listed below:

Reference	Total dose	Sex	Days in Lifetime	Percent animals with cancer
Lijinsky and Taylor (1976)	50 mg	F	840	75
	300 mg	M	700	47
Eisenbrand et al. (1976)	5,000 mg	M	167	29
Lijinsky and Schmahl (1978)	600 mg/kg	M	630	21
	600 mg/kg	F	840	57

The studies by Eisenbrand et al. (1976) and Lijinsky and Schmahl (1978) reported 10 and 0 percent cancer in the control. The Lijinsky and Taylor (1976) study only had a colony control (zero incidence of cancer). For this analysis, we will assume that a, the spontaneous cancer rate, is zero (the cancers noted in the control by Eisenbrand et al. (1976) were different from those caused by the treatment).

The average daily dose (d) was calculated by dividing the total dose by the average time of exposure. We also assumed that the female rats weighed an average of 0.10 kg and the males weighed 0.2 kg.

Reference	Sex	Average daily dose (mg/kg/day)
L & T	F	0.59
	M	2.14
E et al.	M	29.94
L & S	M	0.95
	F	0.71

The cancer potency, B, was calculated from the linear model by solving for B.

$$R = a + Bd$$

$$B = \frac{R}{d} - a/d$$

$$B = R/d \text{ where } a = 0.0.$$

Using the Eisenbrand et al. 1976 date for example:

$$B = R/d = 0.29/29.94 \text{ mg/kg/day.}$$

$$= 0.0097 \text{ per (mg/kg/day)}$$

Other cancer potencies are:

Reference	Sex	Average dose (mg/kg/day)	Incidence	Cancer potency per (mg/kg/day)
L & T	F	0.59	0.75	1.3
	M	2.14	0.47	0.22
E et al.	M	29.94	0.29	0.010
L & S	M	0.95	0.21	0.22
	F	0.71	0.57	0.80

Extrapolating the cancer potency in rats to humans was done by multiplying by the 1/3 power of human (70 kg) to rat (0.35 kg) weights. Using the Lijinsky and Taylor (1976) data, for example, for female rats:

$$B \text{ (human)} = 1.3 \text{ per (mg/kg/day)} \times (70/0.35)^{1/3}$$
$$= 7.6 \text{ per (mg/kg/day)}$$

Reference cancer potencies for humans are estimated below:

Reference	Sex	Human cancer potency per (mg/kg/day)
L & T	F	7.6
	M	1.2
E	M	0.06
L & S	M	1,2
	F	4.7

A-2. Calculations of Worker Dose

Calculations of worker dose are based on research by Haverty et al. (1983) and various assumptions regarding dermal absorption rate and the amount of protective clothing worn.

Low Protection Scenarios

Assume that face, neck, arms, and hands of workers are unprotected. Assume the following areas for body parts: face, 650 square centimeters (cm^2); neck, 260 cm^2; arms, 2,530 cm^2; and hands, 820 cm^2. The pesticide deposition rates for various body parts are provided in Table 3 of Haverty et al. for hydraulic sprayers. This data is provided in micrograms of herbicide per square centimeter of skin (microgram/cm^2). These deposition rates are multiplied by the surface area of the appropriate body part to get the amount of pesticide deposited. To obtain the average deposition on workers, the mean deposition values from Table 3 of Haverty et al. were used.

Face - 650 cm^2 x 0.04 ug/cm^2 = 26 ug
Neck - 260 cm^2 x 0.06 ug/cm^2 = 16 ug
Arms - 2,530 cm^2 x 0.21 ug/cm^2 = 531 ug
Hands - 820 cm^2 x 0.21 ug/cm^2 = 172 ug
Total = 745 ug

To obtain the high values, two standard deviations were added to the mean.

Face - 650 cm^2 x (0.04 + 0.08 + 0.08) ug/cm^2 = 130 ug
Neck - 260 cm^2 x (0.06 + 0.15 + 0.15) ug/cm^2 = 94 ug
Arms - 2,530 cm^2 x (0.21 + 0.62 + 0.62) ug/cm^2 = 3,665 ug
Hands - 820 cm^2 x (0.21 +0.62 + 0.62) ug/cm^2 = 1,189 ug
Total = 5,081 ug

As noted in the text, the dermal dose will be a function of the dermal absorption rate. The analysis assumes rates of 1 percent, 10 percent, and 75 percent and provides corresponding doses to a 70 kilogram (kg) person. As an example, a 10 percent absorption rate results in dose calculations as follows (average value, low-protection scenario):

745 ug/worker x 1 mg/10,000 ug x 0.10 x worker/70 kg = 0.000106 mg/kg

This dose estimate results from spraying one tree. The dose estimate from spraying 100 trees would be 0.0106 mg/kg (100 x 0.000106 mg/kg).

The dose estimate for the typical protection scenarios assume that only the face and neck are exposed (910 cm^2 total area). Deposition rates for the face and neck are assumed as above. All other assumptions are similar as in the low-protection scenario.

A-3. Animal Doses

Deer and rabbit oral exposure and dose assume:

- postspray concentration of insecticides in browse and food foliage ranges from 10 ppm (realistic) to 100 ppm (worst case).
- a typical deer weighs 60 kg (130 lbs) and eats 1.7 kg (3.8 lbs) field weight foliage per day. A typical rabbit weighs 2.0 kg, eats 60 g of food (dry weight) daily, and receives a dose of 0.03 mg/kg/day for each ppm in food (USDA 1984).
- oral dose equals oral exposure.

Thus, the realistic and worst-case doses for a deer due to ingestion would be 0.29 mg/kg/day (10 mg/kg x 1.7 kg/deer/day x deer/40 kg) and 2.88 mg/kg/day (100 mg/kg x 1.7 kg/deer/day x deer/60 kg), respectively.

Similarly, a typical rabbit would have realistic and worst-case doses of 0.3 mg/kg/day (10 ppm x 0.03 mg/kg/day/ppm) and 3.0 mg/kg/day (100 ppm and 0.03 mg/kg/day/ppm).

A-4. Calculation of N-nitrosocarbaryl Dose

Assume two projects per lifetime.

Assume that an individual is affected by both projects and that he receives all possible oral doses (wild food, meat, and water).

Assume the individual receives one dose from wild food after each project, consumes contaminated meat for 14 days after each project, and receives one 2-liter dose of water after each project.

Average "realistic" lifetime carbaryl dose would be:

$d = (00.001)(1) + (0.00002)(14)) \times 2/25{,}550$

$d = 0.000000089$ mg/kg/day or 8.9×10^{-8}

Average realistic" N-nitrosocarbaryl dose:

$$d(N) = 8.9 \times 10^{-8} \times (230/201) \times 0.002$$
$$= 2.0 \times 10^{-10} \text{ mg/kg/day}$$

Worst-case average lifetime carbaryl and N-nitrosocarbaryl doses are 6.7×10^{-7} mg/kg/day and 1.5×10^{-9} mg/kg/day, respectively.

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APPENDIX C

LEAST COST ANALYSIS

APPENDIX C

——MIVEST——
A Computer Program
To Evaluate Forestry
Investment Opportunities

Forestry Organization - US FOREST SERVICE
Organization Subdivision - DEERLODGE
Analyst - DICK SMITH

****
*Project or Program - PESTICIDE EIS *
*Base Problem or Alternative - ALT 1 NO ACTION *
****

Seq. No.	Item	Paymt Type	Years Begin	Years End	Incrd Value Rate	Beginning Year Nondiscounted Total Value	$ Discounted at 4.00% Cost	Benefit
1	REPLACE CAMPGROUNDS	1	5	5	.00	-200000.00	-164385.44	.00
						TOTALS=	-164385.44	.00

****
*Project or Program - PESTICIDE EIS *
*Base Problem or Alternative - ALT 2 CLEARCUT AND PLANT *
****

Seq. No.	Item	Paymt Type	Years Begin	Years End	Incrd Value Rate	Beginning Year Nondiscounted Total Value	$ Discounted at 4.00% Cost	Benefit
7	STUMPAGE(MBF)	1	2	2	.00	1854.00	.00	1714.13
8	PREP-ADMIN(MBF)	1	1	1	.00	-2472.00	-2376.92	.00
9	ED (MBF)	1	2	2	.00	-1030.00	-952.29	.00
10	PLANTING(AC)	1	3	3	.00	-5740.00	-5102.84	.00
						TOTALS=	-8432.05	1714.13

****
*Project or Program - PESTICIDE EIS *
*Base Problem or Alternative - ALT 3 SALVAGE AND PLANT *
****

Seq. No.	Item	Paymt Type	Years Begin	Years End	Incrd Value Rate	Beginning Year Nondiscounted Total Value	$ Discounted at 4.00% Cost	Benefit
7	STUMPAGE(MBF)	1	1	1	.00	364.00	.00	350.00
8	PREP-ADMIN(MBF)	1	1	1	.00	-676.00	-650.00	.00
9	ED (MBF)	1	1	1	.00	-650.00	-625.00	.00
10	PLANTING(AC)	1	2	2	.00	-1435.00	-1326.74	.00
7	STUMPAGE(MBF)	1	2	2	.00	364.00	.00	336.54
8	PREP-ADMIN(MBF)	1	2	2	.00	-676.00	-625.00	.00
9	ED (MBF)	1	2	2	.00	-650.00	-600.96	.00
10	PLANTING(AC)	1	3	3	.00	-1435.00	-1275.71	.00
7	STUMPAGE(MBF)	1	3	3	.00	364.00	.00	323.59
8	PREP-ADMIN(MBF)	1	3	3	.00	-676.00	-600.96	.00
9	ED (MBF)	1	3	3	.00	-650.00	-577.85	.00
10	PLANTING(AC)	1	4	4	.00	-1435.00	-1226.64	.00
7	STUMPAGE(MBF)	1	4	4	.00	350.00	.00	299.18
8	PREP-ADMIN(MBF)	1	4	4	.00	-650.00	-555.62	.00
9	ED (MBF)	1	4	4	.00	-625.00	-534.25	.00
10	PLANTING(AC)	1	5	5	.00	-1435.00	-1179.47	.00
						TOTALS=	-9778.20	1309.31

****
*Project or Program - PESTICIDE EIS *
*Base Problem or Alternative - ALT 4 SEVIN XLR * OPT1 Rate .00 OPT2 Rate 7.13 Ranking Rate 4.00 Inflatn. Rate .00
****

Seq. No.	Item	Paymt Type	Years Begin	Years End	Incrd Value Rate	Beginning Year Nondiscounted Total Value	$ Discounted at 4.00% Cost	Benefit
1	SEVIN APPLICATION	1	1	1	.00	-5794.00	-5571.15	.00
						TOTALS=	-5571.15	.00

++++++++++++++++++++++++++++++++++++++
+ Ordering of Projects or Programs +
+ Based on Respective Ranking Rates +
++++++++++++++++++++++++++++++++++++++

Projects Ranked by Present Net Value

Problem Title	PNV
ALT 1 NO ACTION	-164385.44
ALT 3 SALVAGE AND PLANT	-8468.89
ALT 2 CLEARCUT AND PLANT	-6717.93
ALT 4 SEVIN XLR	-5571.15

APPENDIX D

Public and Agency Comments

R.n..., Box 2068
Whitehall, Montana
March 25, 1986

Dick Smith
Jefferson Ranger District
Box F
Whitehall, Montana 59759

Dear Sir:

I would like to comment on the proposal the Forest Service is promoting to use herbicides and pesticides on trees and around the grounds at Delmoe, Homestake, Lake, and the Elderoreek picnic grounds.

Fifty years ago it was my pleasure to stay in a cabin at Elkhorn Hot Springs. This cabin was in the timber (lodgepole) and very picturesque. However I was extremely concerned because the pine beetle had infected the trees in that area and the Forest Service employees predicted all the trees would be killed. That was years before Dow Chemical and all the other chemical companies had thought of the enormous profits to be made by making pesticides. You can imagine my surprise when some two or three years ago when I visited the area, instead of a completely devastated area devoid of alltimber and vegetation, I found a lodgepole forest of some 30or40 foot trees in the area. Supposedly the area should have been completely devastated. I could hardly believe my eyes.

I realize I am stepping on influential toes when I point out that the forest service is only serving the chemical companies' interests. In this country our forests have grown for some hundreds of years without the direction and guidance of the forest service. It would seem that much of the present direction is misguided in the attempt to make timber a harvestable crop on the order of corn.

Rather than introducing a chemical poison in the soil around these campgrounds the forest service might better consider taking out any trees that die and letting the young trees take the place of the older trees. Because of the increasing amount of pollutants in the land I oppose the broadcast or use of pesticides on the campgrounds or on the US forests at any place where there is even remote danger from their use. The U.S. Forest Service certainly must be aware of the increase in soil and water pollution in this country and should be extremely careful concerning the use of such agents which are posing such a danger to the American public.

E. Carroll Speck

E. Carroll Speck

RECE
APR 3 0
CFPM

1404 Toole Street
Missoula, Montana 59828

April 24, 1986

John Thompson

Please refer me to the date and decision notice for the worse case analysis of human risk for use of the insecticide Carbaryl.

Please also explain why extrapolation of viral enhancement studies on animals to humans is discounted with Carbaryl, yet is used as the sole basis for determining human dermal absorption of herbicides in Region I's worse case analysis for herbicide programs to control noxious weeds.

Please also explain the procedure and preparation of documents in the environmental impact determination process. In other words, please define the role or function of documents, such as Lewis and Clark Forest's herbicide E.A., what it determined, the role of the worse case analysis, and the final E.I.S.

I am trying to determine the status and actual function of each individual part of the process, and the programmatic process as a whole.

Thank you for keeping me informed.

Sincerely,

Rick Torre

United States Department of Agriculture
Soil Conservation Service
Federal Building, Room 443
10 East Babcock Street
Bozeman, MT 59715

April 7, 1986

Frank E. Salmonsen
Forest Supervisor
Deerlodge National Forest
P.O. Box 400
Butte, MT 59703

Dear Mr. Salmonsen:

Appropriate SCS staff have reviewed the draft environmental impact statement "Protection of Individual Trees from Attack by Mountain Pine Beetle". No comments were made as a result of the review.

Thank you for the opportunity to review and comment on this draft EIS.

Sincerely,

Glen H. Loomis
State Conservationist

cc:
James B. Newman, Director, Ecological Sciences Division, SCS, Washington, DC
Robert G. Lohmiller, State Resource Conservationist, SCS, Bozeman, MT

U.S. Department of Transportation
Office of the Secretary of Transportation

400 Seventh St., S.W.
Washington, D.C. 20590

APR 3 1986

Mr. Frank E. Salmonsen
Forest Supervisor
Deerlodge National Forest
P.O. Box 400
Butte, MT 59703

Dear Mr. Salmonsen:

Thank you for the opportunity to review the draft environmental impact statement for Protection of Individual Trees from Attack by Mountain Pine Beetle. The Department of Transportation has no comments to offer.

Sincerely,

Eugene L. Lehr, Chief
Environmental Division
Office of Transportation
Regulatory Affairs

U.S. Department of Housing and Urban Development
Denver Regional Office, Region VIII
Executive Tower
1405 Curtis Street
Denver, Colorado 80202-2349

Rec'd 3/27/86

March 25, 1986

Mr. Frank E. Salmonsen
Forest Supervisor
Deerlodge National Forest
P.O. Box 400
Butte, Montana 59703

Dear Mr. Salmonsen:

This is in response to your request for comments on the Protection of Individual Trees From Attack by the Mountain Pine Beetle Draft Environmental Impact Statement (DEIS).

Your DEIS has been reviewed with consideration for the areas of responsibility assigned to the Department of Housing and Urban Development. This review considered the proposal's compatibility with local comprehensive planning and impacts on urbanized areas. Within these parameters, we find this document adequate for our purpose.

If we may be of further assistance, please contact Mr. Howard S. Kutzer, Regional Environmental Officer, at (303) 844-3102.

Sincerely,

for Robert J. Matuschek
Director
Office of Community
Planning and Development

DEPARTMENT OF THE AIR FORCE
554TH CIVIL ENGINEERING SUPPORT SQUADRON (TAC)
NELLIS AIR FORCE BASE, NV 89191

Forest Service
Deerlodge National Forest
Butte, Montana
MAR 18 1986
RECEIVED

REPLY TO ATTN OF DESEP (Mr. McInerney, (702) 643-4287)

MAR 14 1986

SUBJECT Pesticide Use for Mountain Pine Beetle Control

TO Forest Supervisor
Deerlodge National Forest
Butte, Montana 59701

Request a copy of the Draft and Final Environmental Impact Statement on the subject action be forwarded to the following address:

554 CESS/DESEP
ATTN: Mr. Jim McInerney
Nellis AFB, NV 89191-5000

ANTHONY P. DIAZ, Colonel, USAF
Deputy Commander for
Civil Engineering

Bob - please send me a cy of DEIS + letter
Return this letter
Thanks

State of Montana
Office of The Lieutenant Governor
Helena 59620
(406)444-3111

GEORGE TURMAN
LIEUTENANT GOVERNOR

March 18, 1986

Mr. Frank Salmonsen, Forest Supervisor
Deerlodge National Forest
P.O. Box 400
Butte, MT 59703

Re: Draft Environmental Impact Statement for Protection of Individual Trees from Attack by Mountain Pine Beetle
Montana State IGR Clearinghouse File No. MT860314-475-X

Dear Mr. Salmonsen:

The above-captioned document has been received in the Clearinghouse. In order to provide notification to parties that may be interested in review and/or comment on the proposal, it will be listed in the next Intergovernmental Review Bulletin issued from this office.

Any inquiries regarding the proposal will be directed to Dick Smith at the Jefferson Ranger District. Please provide copies of the enclosed suggested review form to potential reviewers - those you feel should be invited to comment, as well as to any who may request the opportunity to do so. We have asked that comments be returned to your office by May 5, 1986 as requested, and that copies be sent to the Clearinghouse for our files.

The Clearinghouse intends to take no further action on this proposal.

Sincerely,

Sue Heath

SUE HEATH
Clearinghouse Manager

Enclosure

cc: Dick Smith

United States
Environmental Protection
Agency

Region 8, Montana Office
Federal Building
301 S. Park, Drawer 10096
Helena, Montana 59626 0096

FOREST RANGER
JEFFERSON RANGER DISTRICT
WHITEHALL, MONT. 59759
MAY 12 1986
RECEIVED

EPA

REF: 8MO

May 6, 1986

Frank E. Salomonsen, Supervisor
Deerlodge National Forest
P. O. Box 400
Butte, Montana 59703

Re: Protection of Individual Trees from Attack by the Mountain Pine Beetle Draft Environmental Impact Statement

Dear Mr. Salomonsen:

In accordance with our responsibilities under the National Environmental Policy Act and Section 309 of the Clean Air Act, the Region VIII Montana Office of the Environmental Protection Agency (EPA), has reviewed the referenced documents and provides the following comments:

1. Overall organization of the DEIS could be improved. Much of the information which should be up-front in the text is actually contained in the Appendices. Examples are:

   a. Type of protective equipment to be worn (B-16).
   b. Will public be allowed in campgrounds during spraying (B-17).
   c. Re-entry interval (B-18).
   d. Buffer zone around water (B-19).

2. Carbaryl is quite toxic to bees. This is not mentioned in the text. Literature references are briefly discussed on page A-7, but there is no mention of how that affects this project.

3. There is no discussion of preparations made to handle an accidental spill or exposure to any of the workers.

4. There is no mention of training received or skills necessary for applicators. The Montana Department of Agriculture requires that a certified pesticide applicator be involved in the project.

5. There is no mention of a plan for disposal of empty containers.

EPA rates this DEIS EC-2 (Environmental Concerns, Insufficient Information).

Thank you for providing this opportunity for our review and comment on the Draft EIS. If you have any questions regarding the above comments, please call me at 449-5432 in Helena.

Sincerely,

John F. Wardell, Director
Montana Office

cc: Dale Vodehnal, 8PM-EA

TED SCHWINDEN
GOVERNOR

STATE OF MONTANA
DEPARTMENT OF AGRICULTURE
ENVIRONMENTAL MANAGEMENT DIVISION
AGRICULTURE/LIVESTOCK BLDG.
CAPITOL STATION
HELENA, MONTANA 59620-0205

KEITH KELLY
DIRECTOR
(406) 444-3144

GARY GINNERY
ADMINISTRATOR
(406) 444-3144

May 2, 1986

MEMORANDUM

TO: Ralph Driear

FR: John Larson

RE: Deerlodge National Forest Mountain Pine Beetle DEIS

Department of Agriculture staff have reviewed the DEIS on Protection of Individual Trees from attack by the Mountain Pine Beetle prepared by the Deerlodge National Forest. Overall, the DEIS does a good job of covering the problem and most of the alternatives. However, Alternative 6 might be expanded or another alternative considered that includes the use or development of pheremone traps.

The public might be aware of the research being done with pheremones on other species of bark beetles. A summary of these projects including the use of aggregation pheremones to monitor bark beetle populations and potential use of pheremones to congregate beetles into an area for control should be added to the DEIS. This may be interesting information and may stimulate further research into this area. The DEIS should explain why pheremones may or may not be useful for mountain pine beetle control in these areas.

The DEIS should specify the forest habitat types of the treatment areas and indicate whether lodgepole pine is a climax or seral species in these areas. Thinning may be a viable option where lodgepole may be replaced by Douglas-fir or other less susceptible species. The salvage and replant alternative should be carefully considered for Elder Creek and, perhaps, Homestake. Cutting trees for home or campground firewood may save sale costs.

Trees surrounding the recreational areas that die from mountain pine beetle attack may be a fire hazard. The DEIS should address how these trees might be protected or the fire hazard reduced.

The overall goals listed in the DEIS should focus on the proposed project and explain the need for individual tree protection in recreational areas. The vague National Forest policies relating to food and fiber production or preservation of forest resources do not seem to be directly related to project objectives.

An integrated pest management (IPM) approach that utilizes a combination of pest control techniques is the best option for controlling mountain pine beetle infestations. Deerlodge National Forest planners and managers should select the best combination of mechanical, cultural, biological and chemical pest control methods, considering the wide range of economic, social and environmental costs and benefits.

Thank you for the opportunity to review the DEIS. We look forward to your consideration and respose to these comments in the Final EIS.

emr/DNFDEIS

APPENDIX E

List of Agencies and Individuals receiving EIS

DEPARTMENTAL ENVIRONMENTAL
OFFICE, U.S. DEPARTMENT OF HEALTH
AND HUMAN SERVICES
200 INDEPENDENCE AVE SW, RM. 542F
WASHINGTON DC 20201

ASSISTANT SECRETARY OF POLICY
EVALUATION AND RESEARCH
OCCUPATIONAL SAFETY & HEALTH, RM.
N-3673, U.S. DEPT. OF LABOR
WASHINGTON DC 20210

U.S. DEPARTMENT OF THE INTERIOR
ENVIRONMENTAL PROJECT REVIEW
DIRECTOR
INTERIOR BUILDING, ROOM 4256
WASHINGTON DC 20240

SOIL CONSERVATION SERVICE (SCS)
ENVIRONMENTAL COORDINATOR OF
ECOLOGICAL SCIENCES DIVISION
U.S. DEPT. OF AGRIC., ROOM 6155
WASHINGTON DC 20250

ENVIRONMENTAL PROTECTION AGENCY
DIRECTOR
OFFICE OF FEDERAL ACTIVITIES
ROOM 2119 MALL 1401 M ST. S.W.
WASHINGTON DC 20460

ANIMAL & PLANT HEALTH INSPECTION
DIRECTOR'S OFFICE
SERVICE PPQ (APHIS)
AGRICULTURE, ROOM 648, FED. BLDG.
HYATTSVILLE MD 20782

U.S. FISH & WILDLIFE SERVICE
FEDERAL BLDG., ROOM 3035
315 NORTH 26TH STREET
BILLINGS MT 59101

BOULDER MONITOR
VERNON SUTHERLIN
P.O. BOX 66
BOULDER MT 59632

INTERGOVERNMENTAL CLEARING HOUSE
STATE CAPITOL, ROOM 219
HELENA MT 59620

JEFFERSON COUNTY COMMISSIONERS
CHAIRMAN
COUNTY COURTHOUSE
BOULDER MT 59632

SKYLINE SPORTSMEN
TONY SCHOONEN, PRESIDENT
P.O. BOX 173
BUTTE MT 59701

ANACONDA SPORTSMEN'S CLUB
CHRIS MARCHICN, PRESIDENT
2103 GARFIELD
ANACONDA MT 59711

BUREAU OF LAND MANAGEMENT
GARY K. LEPPART
HEADWATERS MANAGER
P.O. BOX 3388
BUTTE MT 59702

MONTANA DEPARTMENT FISH,
WILDLIFE AND PARKS
REGION 3
BOZEMAN MT 59725

WHITEHALL LEDGER
WHITEHALL MT 59759

KATHY HADLEY
BOX 835
DEER LODGE MT 59722

BRUCE REHWINKLE
P.O. BOX 251
WHITEHALL MT 59759

AGRICULTURE STABILIZATION AND
CONSERVATION OFFICE
405 WEST LEGION
WHITEHALL MT 59759

JEFFERSON VALLEY SPORTSMEN ASSOC.
DAVID C. COLE, PRESIDENT
P.O. BOX 6
WHITEHALL MT 59759

ENVIRONMENTAL LIBRARY
UNIVERSITY OF MONTANA
MISSOULA MT 59812

HELENA NATIONAL FOREST
FOREST SUPERVISOR
FEDERAL BUILDING, DRAWER 10014
ROOM 334
HELENA, MT 59626

HEADWATERS RC & D
ROOM 101, FEDERAL BUILDING
400 N. MAIN
BUTTE, MT 59701

GLEN H. LOOMIS
FEDERAL BUILDING, ROOM 443
10 EAST BABCOCK
BOZEMAN, MT 59715

SOIL CONSERVATION SERVICE
STATE CONSERVATIONIST
BOZEMAN, MT 59715

BEAVERHEAD NATIONAL FOREST
FOREST SUPERVISOR
DILLON, MT 59725

LOLO NATIONAL FOREST
FOREST SUPERVISOR
BUILDING 24, FORT MISSOULA
MISSOULA, MT 59801

MONTAN FISH, WILDLIFE AND PARKS
3309 BROOKS
MISSOULA, MT 59801

BUREAU OF LAND MANAGEMENT
DISTRICT MANAGER
P.O. BOX 308
BUTTE MT 59701

HEADWATERS R.C. & D.
ROOM 101 FEDERAL BLDG.
400 N. MAIN
BUTTE MT 59701

ARMY CORPS OF ENGINEERS (COE)
HEADQUARTERS, ATTN: DAEN-ZCE
WASHINGTON, D.C. 20310

U.S. AIR FORCE (USAF)
DEPARTMENT FOR ENVIRONMENT &
SAFETY (SAF/MIQ)
WASHINGTON, D.C. 20330

U.S. NAVY (USN)
OFFICE OF CHIEF OF NAVY OPERATION
ENVIRONMENTAL PROTECTION AGENCY
OP-45, ROOM BD766, PENTAGON
WASHINGTON, D.C. 20350

FEDERAL ENERGY REGULATORY COMM.
ADVISOR ON ENVIRONMENTAL QUALITY
825 NORTH CAPITAL STREET, N.E.
WASHINGTON, D.C. 20406

FEDERAL ENERGY REGULATORY COMM.
DIVISION OF ENVIRONMENTAL ANALYSIS
PATRICIA ASPLAND
ROOM 304B, 400 1ST, STREET N.W.
WASHINGTON, D.C. 20436

OFFICE OF ENV. COMPLIANCE 2WP
DIRECTOR
DOE, ROOM 3 G-092, PE-25
1000 INDEPENDENCE AVE., S.W.
WASHINGTON, D.C. 20585

ASSISTANT SECRETARY FOR POLICY &
INTERNAL AFFAIRS, U.S. DEPARTMENT
OF TRANSPORTATION, ENV. DIVISION
(P-37), RM. 10223, 400 7TH ST., S.W.
WASHINGTON, D.C. 20590

ENVIRONMENTAL PROTECTION AGENCY
ETS REVIEW COORDINATOR
REGION VIII
1860 LINCOLN STREET
DENVER CO 80203

BITTERROOT NATIONAL FOREST
FOREST SUPERVISOR
316 NORTH 3RD STREET
HAMILTON, MT 59840

ENVIRONMENTAL PROTECTION AGENCY
JOHN WARDELL, DIRECTOR
FEDERAL BUILDING
301 SOUTH PARK, DRAWER 10096
HELENA, MT 59626

INTERMOUNTAIN RNG. & EXP. STATION
KEITH EVANS, ASD
507 25TH STREET
OGDEN, UT 84401

Mr. E. CARROLL SPECK
R.R. 2, BOX 2068
WHITEHALL, MT 59759

FOREST PLANNING
P.O. BOX 3479
EUGENE, OR 97403

U.S. COAST GUARD (USCG)
ENVIRONMENTAL IMPACT BRANCH
MARINE ENVIRONMENTAL & SYSTEMS
G-WEP-47/73 - 2100 2ND STREET S.W.
WASHINGTON, D.C. 20593

Mr. RICK TORRE
1404 TOOLE STREET
MISSOULA, MT 59828

BUREAU OF LAND MANAGEMENT
STATE DIRECTOR
316 NORTH 26TH STREET
BILLINGS, MT 59101